Monumental Museum for Onkalo Nuclear Waste Repository

: Onkalo, Focus on Interaction between life-form with Space

Sanyung Lee, Master Diploma Thesis
Oulu School of Architecture, University of Oulu

Supervisor
Aulikki Herneoja

5/5/2018
Sanyung Lee

Information

Master Diploma Thesis

Oulu University, School of Architecture

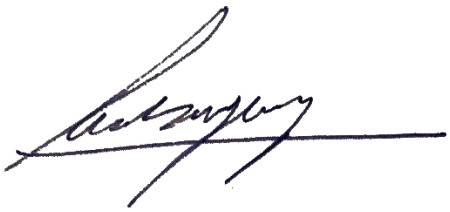
Title: Monumental Museum for Onkalo Nuclear Waste Repository

Author: Sanyung Lee

Supervisor: Aulikki Herneoja

2 documents: written thesis (49 pages), design panels (5 pages), plans (20 pages)

Date: 5/28/2018



*For further understanding, I recommend you watch the movie about the sequences in OMM

Movie Link

You can use QR code with your smartphone.

Abstract

Contemporary civilization needs diverse resources to maintain its form, such as agriculture, knowledge, engineering, infrastructure, and energy, of course. In terms of the energy, the nuclear power is the thickest column to support our present civilization. However, sometimes the bigger advantage you get means the bigger responsibility you embrace. The powerful source of energy, nuclear power causes the crucial side effect behind which is tons of nuclear wastes, which is highly radioactive. Fortunately, many countries which own nuclear power plants are already working on this issue but still most of countries have no specific back-up plan how to deal with these critical but inevitable burdens. Finland is the fore-runner in this field and the Onkalo nuclear waste repository is one of a kind in this important subject. Still the Onkalo is in the middle of research and engineering level right now, but it will be face the cultural and architectural questions for the Onkalo soon. As an echo of this subject the Onkalo will face, I propose the public facility to fulfill the additional needs and purposes of the Onkalo. OMM-Onkalo Monumental Museum which I am proposing will be the one of options for these demands. It can be a museum to memorize the place, the facility to maintain the place, the shelter to protect the place, and the hub to connect present to future.

Keywords: Nuclear waste, Seal, Interaction, Monument, Museum.

Contents

1 Introduction

The Onkalo is newly designated nuclear waste repository facility in Finland. Now it is under the construction for research at the nearby Olkiluoto-Nuclear Power Plant, municipality of Eurajoki, west coast of Finland. Until 2020, the Onkalo will do the research for the bed rocks and soil and confirming the legibility of the site for the permanent nuclear waste repository. The Onkalo project will be the good example of this field-nuclear waste treatment. This is because, now is the time that the humankind need to deal with the inevitable consequences of using nuclear power. My diploma thesis's main topic is deeply related with this background.

I studied background of Finland-Sweden cooperated nuclear treatment policies and technologies to understand why and how the Onkalo planned.

To support cognitive interaction program's reliability, I familiarize myself the researches about human interaction with spaces, symbols and atmospheres.

I planed the monumental public facility that helps to enlighten the people who want and need to know about the Onkalo, nuclear power and followings.

Through this diploma thesis, I propose the example public facility for the Onkalo, especially after its waste storing starts or ends.

The commentary of my diploma thesis compiles of background studies, example projects, and developing processes. And to support the ground of theory, the design part is included. The design part contains specimen project analysis, organizing result of analysis, generating practical solution and utilize solution in architectural project.

As a result, it is expected that this design part-OMM project- can be one of the solutions for the next step of the Onkalo facility.

1-2 Foundation of the project ideas

I am a student of Finland, even though I am not a Finnish. I spent almost two years in Finland but because of international mood of school and open-minded young Finnish students, I did not have much deep understanding in Finnish society or mindset. The enlightenment came from unexpected place, the documentary about nuclear repository in Finland. I was amazed by the clear perspective towards in this sensitive topic, and I moved how deep Finland and Sweden treat the Nuclear waste issues with the care for the next generations. I imagine if I can be a part of this amazing project, but I am just a student for now. Thus, I decide to figure out what I-

architect-can do in this project. For now, the Onkalo is entirely civil engineering project. I realize that the needs for certain facility will arise, such as further research, informative space, and facilities to keep the Onkalo away from the civilization.

1-3 Inspiration: Into the Eternity

"We recognized that this could happen. That you might find an open Onkalo. We refer to that as "human intrusion". We don't want this to happen because you may get hurt. But most of all - we are afraid of human intrusion because if Onkalo is opened, the waste will no longer be isolated from all living organisms and we will have failed. In fact, we consider you the main threat to the safety of Onkalo." – Into Eternity

Into Eternity is a documentary film directed by Danish director Michael Madsen, released in 2010. Into Eternity follows the construction and background philosophy of the Onkalo waste repository. Director Michael Madsen walk into the processes of Onkalo and its intended eternal existence. The focus of the documentary is introducing Onkalo and questioning the meaning of the Onkalo. I saw this documentary by chance with no background information.

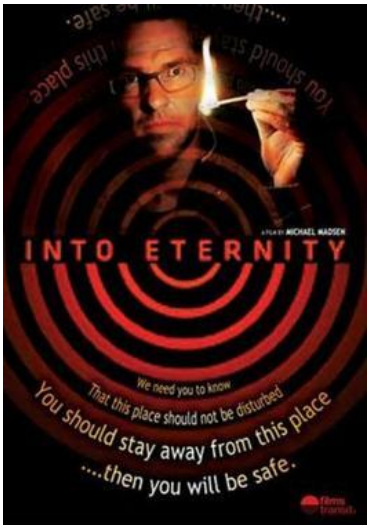


Figure 1 the poster of Into Eternity (Into Eternity 2010)

In Korea-country where I am from- we still arguing for location of nuclear plant because NIMBY problem. We also have nuclear waste repository, but all facilities are temporary one. In addition, these facilities are on the grid and they need continuous attentions of human and resources. In Korea, 30% of energy is coming from nuclear plant and 24 piles are already there. This is 6th largest amount of nuclear piles around the world. However, in terms of treating

nuclear waste remains toddler state. I have to say after rapid development during 70s - 90s, Korean government mainly focused on speed and efficiency. And we did focus on mainly on the results, not the residues. Even though, post processing and waste treatment of nuclear resources are immediate affairs, still, these topic's view in Korea is vague.

With my background, for me, the Onkalo project in Finland and all national procedures related with it are shocking. And it drove me to get interested in the Onkalo more. After the days of research for the Onkalo, I realized that still there is no architectural preparation after completion of the Onkalo-of course there will be something, but for now there is any architectural approaches at all. I started to think about the role of architecture in the Onkalo project.

In my opinion, there are several aims of architectural perspective.

First, Onkalo is the symbol of the belief in future intelligence life form. Not only for the humanity, for possible intellectual life form, this symbol should be noticeable beacon of warning and caution. Future is unpredictable. Thus, the starting point can be to build artificial structure which can hide the Onkalo from possible incursions. which can show the importance of Onkalo, and which can deliver the information to next generations.

Second, at least, while our civilization, we need to deliver the information about what remained the underneath of the Onkalo. The most effective way to do this might be achieve through making astonish monument which also can show the information of Onkalo.

Third, the architecture itself should inform that this is dangerous place and keep this place away from possible contacts. What I propose to do this is that the building itself should be most uncomfortable and annoying place to stay.

Forth, after storing the nuclear waste, facility must be sealed for good. The solution for this issue is that the access to the Onkalo and facility need to be inaccessible after storing nuclear waste in various ways.

If I succeed to archive these conditions, the structure will not only proper architecture for the Onkalo, but also the proper facility for maintaining and informing about the sealed place-the Onkalo.

2 Onkalo

Before getting into the topic, I want to point out some important issues beforehand. We all know what nuclear power plant and nuclear power is. However, specific meaning of terminologies might not familiar than we thought. In addition, nuclear waste repository is quite a new concept for the public. Thus, I try to address couple of important terminologies beforehand of main contents.

2-1 Defining Terminologies

The Onkalo-spent nuclear plant fuel repository in Finland-is a deep underground geological repository for the final and permanent disposal of nuclear waste from the nuclear power plant. It is the first and true 'permanent' nuclear waste repository in the world for now. The Onkalo is currently under construction at the nearby Olkiluoto Nuclear Power Plant in the municipality of Eurajoki, by the company Posiva[1]. The Onkalo's main storing mechanism is KBS-3 [2] nuclear waste container developed by Svensk Kärnbränslehantering AB (SKB) in Sweden. The facility is being constructed by and will be operated by Posiva.

Figure 2 Bird view of Onkalo (Posiva, 2014)

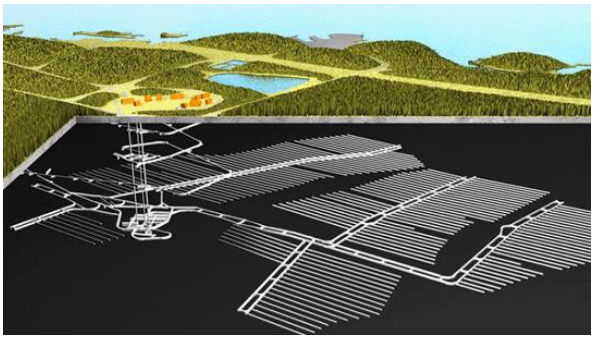


Figure 3 Construction plan illustration (Posiva, 2014)

Following descriptions can cover up how this container works. When the Onkalo starts its operation, the storing disposal waste for the one KBS-3 container will include twelve fuel assemblies into a steel canister like container and enclosing it into a copper capsule. Each

[1] *Posiva Oy is an expert organization responsible for the final disposal of spent nuclear fuel of the owners. Posiva has been established in 1995.*
[2] *Specially designed container type waste storing mechanism.*

sealed capsule will then be moving to designate its own hole in the repository and packed with bentonite clay-effective waterproofing material.

Figure 4 KBS-3 unit (Posiva 2014)

The Onkalo repository is designed to be large enough spaces to accept all spent nuclear fuel in a hundred year. Thus, the final storing and burying will be done in 2120, and the access tunnel entrance will be covered and sealed for good.

Nuclear fuel means the raw material which can be used as a fuel of nuclear reactor. The Uranium-mainly considered as a fuel of reactor-on the Earth is abundant but the one can be used as a nuclear fuel is quite rare, just 0.7 percentage of natural Uranium are 'fissionable'. Capability of fission means can be a starter in nuclear reaction-the process that the energy is produced in a nuclear reactor. The natural form of Uranium which can fissile is the Uranium-235 (U-235) isotope-main fuel of reactor. The other Uranium which left is Uranium-238 (U-238)[3].

[3] U-238 is fissionable in fast neutron reactors, which are likely to be in wide use by mid-century.

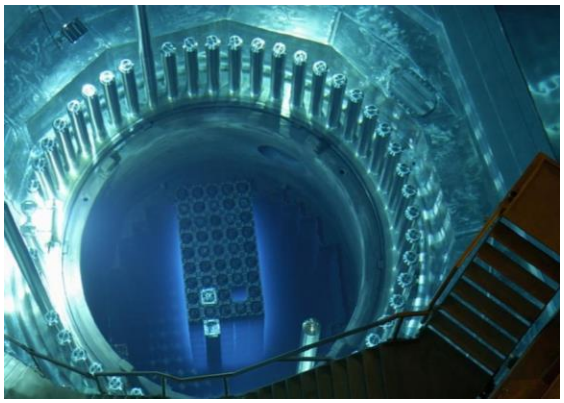


Figure 5 left, Uranium 235 (Public Domain 2007)

Figure 6 right, Nuclear reactor (Kernkraftwerk Gosgen-Daniken Public Domain)

Radioactive waste and **Radiation** are key terminologies to understand the meaning of the Onkalo and other attempts of planning nuclear waste treatment facility. Radiation is the emission or transmission of energy in the form of particles through space or through a material. More simply, something invisible energy particle which can penetrate almost everything. Crucial part of radiation is that can break or manipulate organism's DNA structure in bad way and this can cause life to death. After utilization as a nuclear power source, yet still these materials got strong radiation which can cause critical consequences. And include this nuclear material, every stuff which contains high radiation from nuclear plant are what we called **radioactive waste**. Wastes from the nuclear fuel cycle are categorized as high-, medium- or low-level wastes by the amount of radiation that they emit. Low-level waste produced by at all stages of the nuclear fuel lifecycle. Medium-level waste produced by during reactor's operation, and nuclear fuel's reprocessing. High-level waste which are highly-radioactive materials extracted from reprocessing and nuclear fuel itself.

To store high-level radioactive nuclear material, it must be reprocessed before storing. Fuel reprocessing means extracting usable Plutonium fuel and separating radioactive waste in categories. After reprocessing with the extremely high heat, high-level radioactive waste will turn into powder state, and contained in specific glass canister. The glass canister moves into steel container, and each steel container holds around 400 kg of glass canisters. A year's waste from a 1000 MW size nuclear reactor generates five tons of this kind of canisters. The size of the first reactor of the Olkiluoto Nuclear Power Plant is 880 MW and there are three reactors with similar size.

Half-life of radiation is the time length which radiation strength decreasing in nuclear materials. It depends on the what kinds of nuclear material. For instance, Plutonium's half-life is about 24,000 years long. Different atomic material got different half-life.

Final disposal storage means the place that store nuclear waste for good, not temporary. Most of nuclear waste storages for nuclear waste around the world are temporary storage which means needs maintenance such as cooling. To make these wastes safe from the life form, it needs incredibly long time to keep them away from the environment. Thus, these temporary storages cannot be the ideal solution to deal with nuclear waste. This is the one main reason why the Onkalo is important specimen.

Figure 7 left, Ontario temporary nuclear waste storage (Weil 2015)

Figure 8 right, Waste Isolation Pilot Plant (Jessica Morrison 2013)

2-2 Background of the Onkalo

Preparation for the final disposal facility of spent nuclear fuel in Finland began in the late 1970s. The idea how to treat the nuclear waste in Finland was originally disposing spent nuclear fuel in abroad. Despite this, Finnish government decides final disposal of spent nuclear fuel remains in Finland.

The site for repository was selected in 2000. Teollisuuden Voima(TVO)[4] conducted some researches about the final disposal in the 1980s and 1990s. However, Imatran Voima(IVO) [5] exported its spent nuclear waste to the Soviet Union. In 1994, the Nuclear Energy Act in Finland

[4] TVO is a Finnish nuclear power company.

[5] IVO was Finnish government owned energy production company and ended in 1998. Merged into Fotum Corporation.

announced to implement, according to Nuclear Energy Act, *'which all nuclear waste must be treated, stored and disposed of in Finland, and no nuclear waste from other countries shall be imported into Finland'-Finnish Nuclear Energy Act 990*. After this, TVO and IVO established Posiva Oy to take care of the implementation of the Energy Act.

Site researches associated with choosing the final disposal placement proceeded periodically. First stage, 1983 – 1985, Screening study of the entire area of Finland was conducted. Second stage, 1986 – 1992, fundamental site investigations were done. Third stage, 1993 – 2000, detailed site investigations and an environmental impact assessment were implemented. As a result, four possible areas-Romuvaara in Kuhmo, Kivetty in Äänekoski, Olkiluoto in Eurajoki, and Hästholmen in Loviisa. And Olkiluoto-are Selected.

Researches include site analysis, environmental impact, and safety matter. And all possible areas would be suitable for final disposal site. The local citizen's positive support was highest in Eurajoki and Loviisa. Among these, the Olkiluoto in Eurajoki had a larger area already for the facility. In addition, the larger amounts of the spent nuclear fuel were already there. The repository application was submitted to Finnish government by Posiva in 1999. Finnish government received the agreement from Eurajoki municipal council, and final decision for the repository site made in December 2000.

2-3 Present states of the Onkalo

The Onkalo's constructions plan is divided into four phases. Phase 1 (2004–2009) focused on excavating the access tunnel which is spiraling downward ramp to a depth of 420 meters. Phase 2 (2009–2011) is the excavation until the final depth 520 meters. The property of the bedrock was investigated to adapt the layout of the repository. Posiva got the official license for the construction in November 2015. **Phase 3 is the construction of the repository and it is expected to begin around 2015– current situation.** Phase 4, the sealing and burying of areas filled with spent fuel will begin around 2020. Now the Onkalo is on phase 3 which means on the track of construction. And until 2020, research area and main chamber area will be done. When the Onkalo starting to store nuclear waste, they going to dig extra tunnels just for repository space.

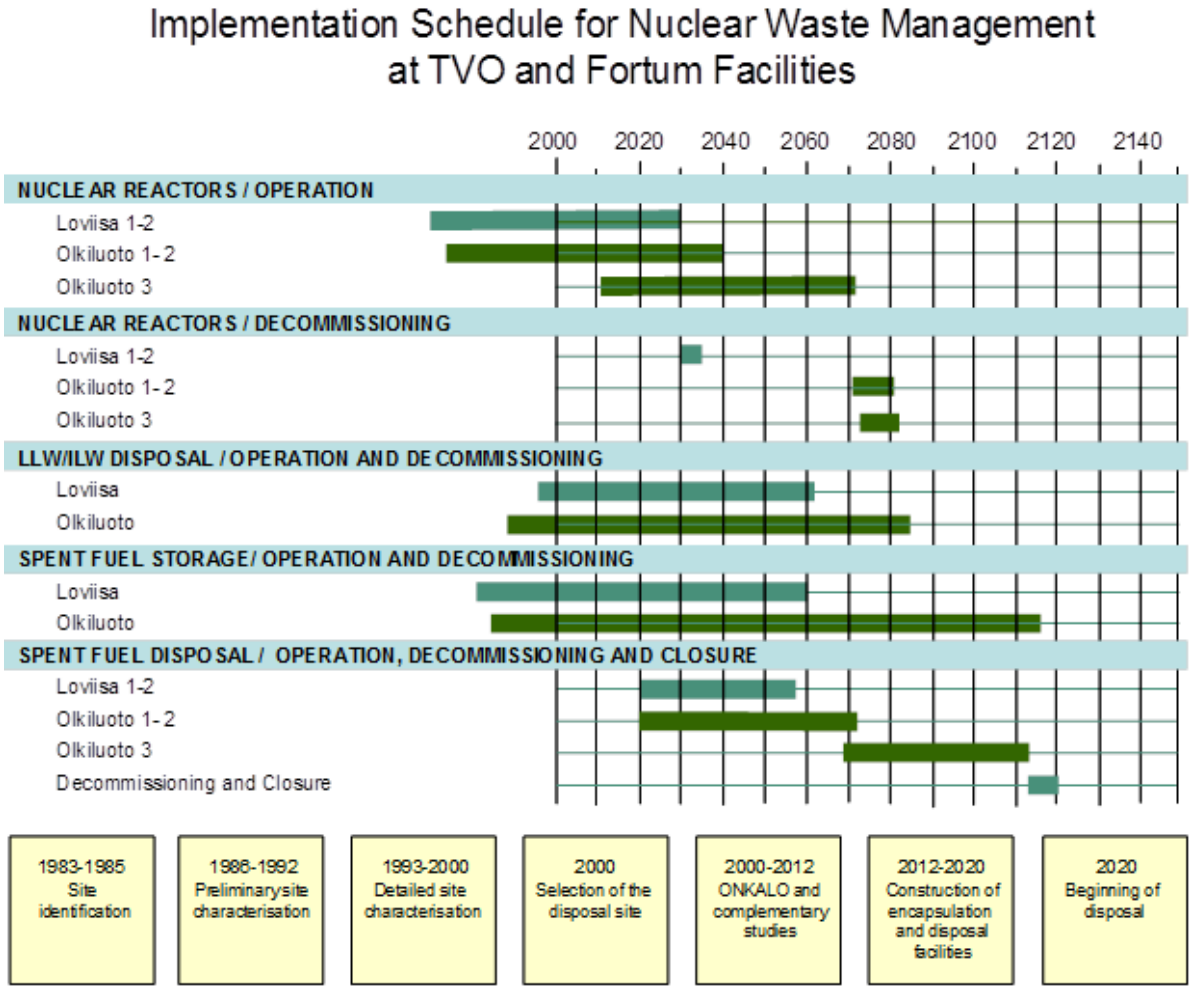


Figure 9 Time line of the Onkalo (Finnish NPP n.d)

4 Seals: description

There are discussion which you can see in Into Eternity about how to make the Onkalo more secure from possible intrusions. Referring the planners of the Onkalo, these ‘markers’ are for future protection from possible incursions. When it comes to these markers-what they called ‘the Seals’-, they are considering between the several sealing methods to warn possible incursions.

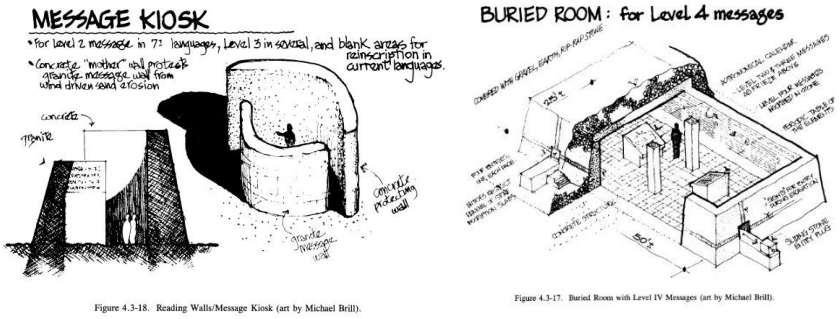


Figure 4.3-18. Reading Walls/Message Kiosk (art by Michael Brill).

Figure 4.3-17. Buried Room with Level IV Messages (art by Michael Brill).

Figure 10 seal example illustrations (Michael Brill 1993)

No matter what kinds of form it is, the main meaning of the seal is informing the warning sign to intellectual life form who might try to get in the Onkalo. Basically, these seal’s availability is only for how to deal with who or what might not use the language like same we do. Thus seals need to deliver meanings indirect ways with this reason. Consisting elements for seals are material, shape, symbol, color, and other abstract methods. The seals must be independent, durable, clear, and simple.

4-1 Seals: none human

Most concerned occasion which possibly occurs in future is incursion of intelligent life form which cannot understand the language. Until now, the seals of the Onkalo based on this possibility which is the consideration of none language intellectual being. OMM project, my diploma thesis also referencing this idea and OMM’s main program follows these seals as well. This is because the main long-term purpose of OMM is to enhance the functional points of the ‘SEALS’. The way to present how dangerous this place is mainly using the signs and symbols.

What we need to show are warnings about the place. To deliver this, we need general gesture of fear, danger, death, and negative images. And it must be easy to understand such as creepy shapes or scary symbols, such as spike field.

Figure 11 reference images of spike field (Containment 2013)

But we never know what kind of 'things' will visit the Onkalo thousands of years later. As documentary 'Into the Eternity' addressed, we just give our hope in this plan with ideal wishes which the Onkalo can avoid possible incursion.

The problem is that there is no universal marker for inter-lifeform and we never know in which evolution leads us and nature. However, there is a clue that we can refer how to deliver negative images in universal way. The dictionary which we can refer when we design these markers is nature. This is because, through billions year, nature succeed to make universal symbols of danger. For instance, **spiky thorn, vivid color, and strong scent**. The list that I mentioned are typical warning sign in nature, but these are just categories so still it gives us the clue but hard to generalize. However, we still can use these methods when we prepare the seals for non-human.

4-2 Seals: for human

For the mankind, at least within the era which can share our civilization, it is easy to inform what is underneath of the Onkalo. If we use our knowledge, basically we can use our language to give information to possible intruders. Even if future mankind who might not use the same language format, if he or she or thing is still 'human', we can predict what possibly they understand or feel. Thus, when we design the seals for mankind, human, it might be more comfortable to build than for non-human seals. For instance, the symbol like the human skull, the painting like the scream by Edvard Munch[6], and 'X' mark on human diagram are quite common warning message for human knowledge.

Figure 12 left, Examples of warning signs in general for mankind categories. (Public Domain)

Figure 13 right, Scream (Edvard Munch1893)

However, there is also considerable weakness in this proposition. For instance, think about old relics and ruins like the pyramids in Egypt. There were diverse warning signs, but those signs were also draw pure curiosity of the people who discover. Even though Egyptian used language with high intellectual level, after thousands of years make separation between civilizations and hard to understand each other. Because of these uncertainty in continuity of civilization and language, we need universal sign, but on the contrary, it got risk that can give the sources of curiosity, like well-hidden place for treasures, indefinite markers might lure more incursions.

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[6] Referring the Edward Munch's Scream as a sign of warning mentioned in documentary Into Eternity by Mikael Jensen.

5 Reference projects

Nuclear waste repositories are simple huge underground vault or facilities with machineries with thick containers. However, what I try to do in this project is to build monumental public facility for the Onkalo. The reference that I am looking for is not just the other kinds of deep geological repository. Reflecting the aims that I need for OMM, I choose reference project depends on following four perspectives. First perspective is the way of operating the facility. To refer this aspect, I choose **Svalbard Global Seed Vault.** Second is the way of forming spatial sequences. To refer this aspect, I choose **Chichu Art Museum.** Third one is the way of planning unpleasant space. To refer this aspect, I choose – **Jewish museum in Berlin**. Last one is the way of forming monumental structure. To refer this aspect, I choose **featured monuments from Soviet Union.**

5-1 Svalbard Global Seed Vault

The Svalbard Global Seed Vault (Norwegian: *Svalbard globale frøhvelv*) is a permanent seed repository on the Norwegian island of Spitsbergen nearby Longyearbyen in Arctic Svalbard archipelago, about 1,300 kilometers from the North Pole. The consultative Group on International Agricultural Research (CGIAR), initiated the vault to preserve plant seeds that to maintain samples, or to store copies of seed. The main function of the seed vault is ensuring the seeds around the world from massive crisis such as meteorite extinction. The Norwegian government entirely funded the vault's construction. Using vault is basically free for everyone, and all expenses paid by Norway government and Crop Trust foundation.

Figure 14 left, Svalbard Seed Vault (Global Crop Diversity Trust n.d)

Figure 15 right, container of the seeds (Riccardo Gangale 2018)

Basically, Svalbard vault does not take any visitors except designated special occasions. The one that I try to refer is its simple layout. Still, Svalbard vault does not need huge structure, but Svalbard vaults well controlled in-and-out program is impressive. Of course, there is only one entrance, so it seems obvious but important point is they planned long corridor for reasons. Reasons are to get enough distance to designated depth and to maintain airflow space. Seed vault is vulnerable with micro climate, so they need low but stable dry air tighten space. Like I mentioned before, one of the important factor that can use to manipulating people emotion is temperature with micro climate. Svalbard vault's climate control can be referring.

5-2 Chichu Art Museum

The Chichu Art Museum (地中美術館 Chichu Bijutsukan) (literally "art museum under the earth") is a museum built directly into the earth of a southern portion of Naoshima island in Kagawa Prefecture, Japan. It was designed by architect Tadao Ando who is one of the most important Japanese architect with Pritzker Prize winning and it opened on July 18, 2004. The site, Naoshima, was deserted after extracting raw resources. The Banesse foundation planned to revive this island into art theme area, and Tadao Ando designated as a head architect. Despite of its position buried deep underground, the design of the building itself use abundant natural lights. Not only exhibition chambers, but also passage between spaces and volumes are changing their appearance with lights throughout the day. What interesting in this subterranean building is that the visitors cannot read the whole shape of building, even though after they explore the building, still hard to read the shape. People who visit museum enter through one entrance and come out through the same gate. Program circulation seems one way, but visitors can wandering between exhibition chambers through amazing open-air passages. There is no designated viewing order, but if visitors follow main passage, they can walk through entire collections of the museum. During experiencing museum, people might have no idea where they are, but at the last part of passage is art shop and they can check some photos which documented aerial view of Chichu museum. When you see the Chichu Art Museum from a distance, it just looks like scattered structure. Even if you see the diagram, it looks like the combination of simple geometry and each geometry got their own purposes. Simple but purpose-fulfilled circulation design can be referring from Chichu Museum.

Figure 16 aerial photograph of Chicu Museum (Banesse foundation n.d)

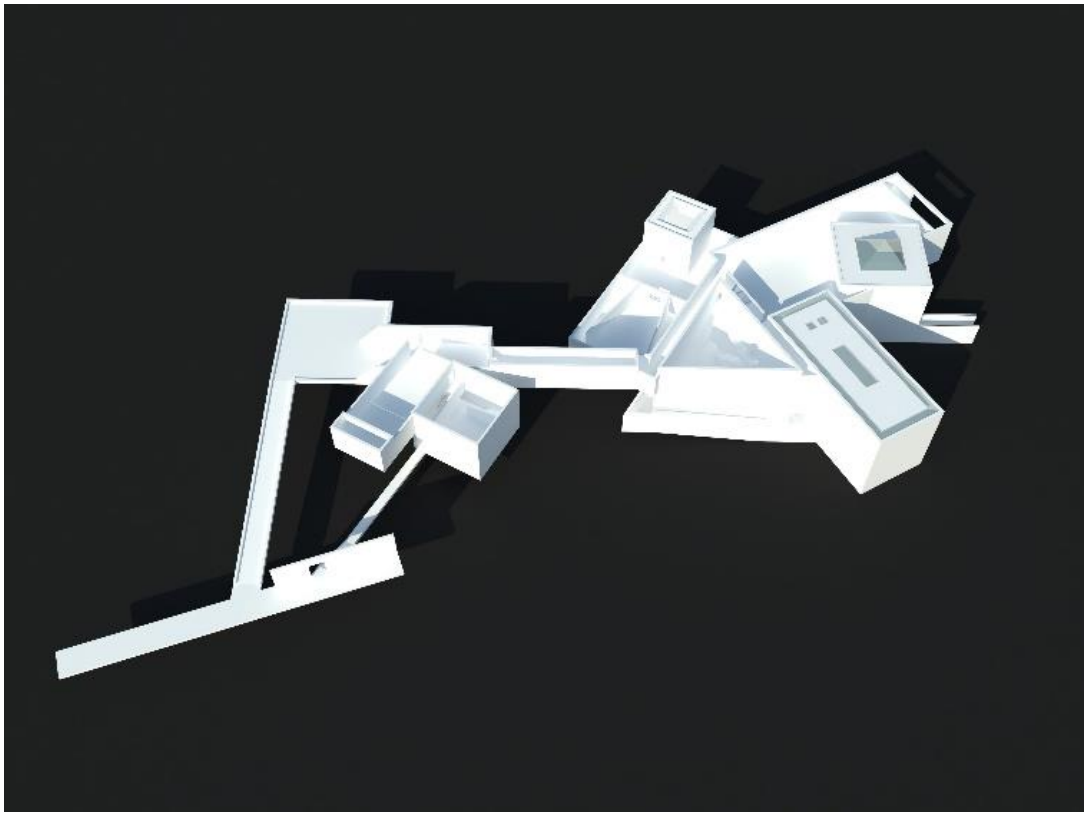


Figure 17 3D model of Chichu Muesum (Albert Lee n.d)

5-3 Jewish museum in Berlin

Jewish museum is very famous architecture designed by Daniel Libeskind. It reveals to public in 2001 and awarded multiple prizes. It is an extension of classic building which is Baroque Kollegienhaus, and the entrance of museum placed in this old building.

Figure 18 perspective of Jewish Museum (Bitter Bredt n.d)

When Libeskind design the museum, one of important thing in this building is circulation. Circulation and the experience while along the passage are main contents of all museums but Jewish Museum made it more dramatic and dynamic. Here is description from Studio Libeskind's website.

'The visitor enters the Baroque Kollegienhaus and then descends by stairway through the dramatic Entry Void, into the underground. The existing building is tied to the new extension, through the underground, thus preserving the contradictory autonomy of both the old and new structures on the surface. The descent leads to three underground axial routes, each of which tells a different story. The first leads to a dead end – the Holocaust Tower. The second leads out of the building and into the Garden of Exile and Emigration, remembering those who were forced to leave Berlin. The third and longest, traces a path leading to the Stair of Continuity, then up to the exhibition spaces of the museum, emphasizing the continuum of history.'

– Studio Libeskind

As we can read in this description. Circulation of this building is the main design point to deliver the meaning of the museum and the architect's philosophy. And continuous circulation between spaces forming the building shape unique as well. Architect, Libeskind, use this circulation as a main theme of experience for visitors to learn what happens to Jews in history with indirect way. What I call, cognitive interaction between space and people. There are more complicate connection and intension are in the program of the building, but I am not going to address here.

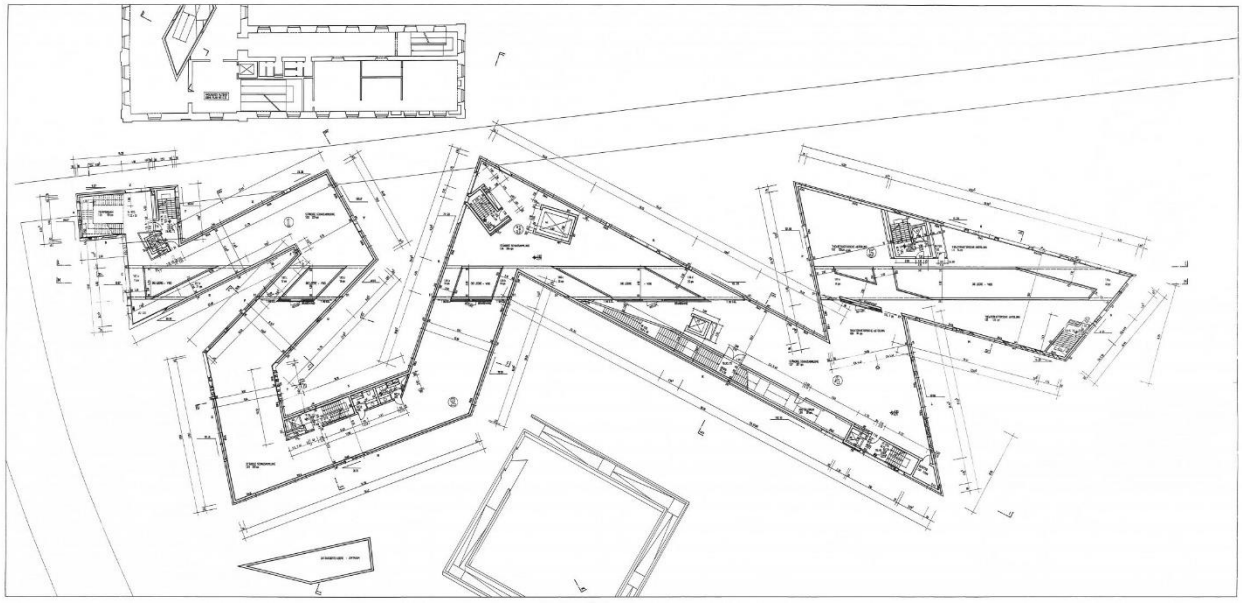


Figure 19 floor plan of Jewish Museum (Studio Libeskind 2001)

What I focused on is the continuity of circulation and the methodology of atmosphere. Each context of museum linked in harmony with proper means. There are many of voids as you can see in the plan, and it works as a space separator and also it forms exotic borders between space, void, corridor and exhibition.

'A void cuts through the zigzagging plan of the new building and creates a space that embodies absence. It is a straight line whose impenetrability becomes the central focus around which exhibitions are organized. In order to move from one side of the museum to the other, visitors must cross one of the 60 bridges that open onto this void'. – Studio Libeskind

It might be similar with the other reference that I mentioned before-Chichu Museum, which they use void to give interesting experience to the visitors. Jewish Museum's sacred but uneasy mood and continuous circulation are interesting.

5-4 Monuments from Soviet Union architecture

Period of USSR was not amusing time for sure, for all around world. However, when it comes to the architecture, especially monuments for propaganda are one of a kind. Needless to say, these monument's aesthetics are amazing. Let the propaganda behind, their experiments on structures, materials, scales, and boldness literary catch our eyes. Why I pay attention on these ideological architectures is their unique monumentality which is what I need to apply on OMM. I will mention couple of examples for reference.

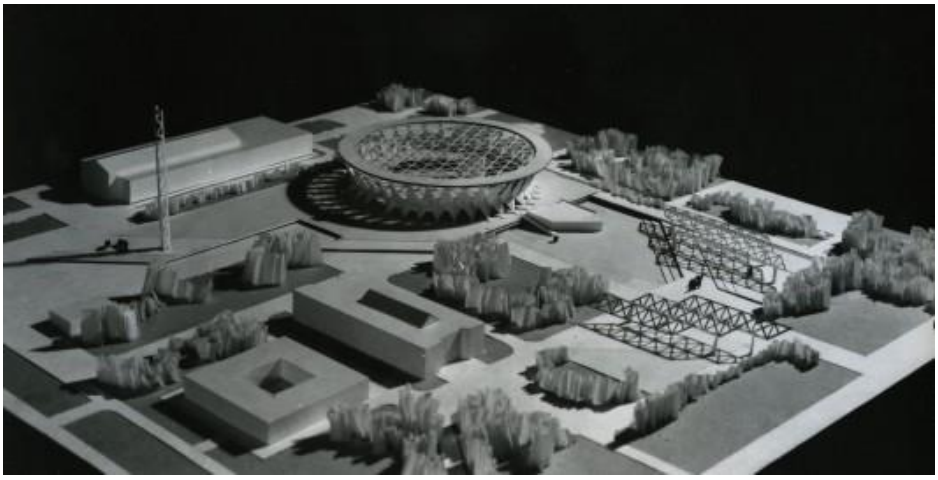


Figure 20 Universal Pavilion with pneumatic structures (Valentyn Shtolko n.d)

Universal Pavilion is unbuilt one. But I think the structure and formation of pavilion are interesting. The supporting structure seems two types, truss and unique column. However, the geometry what we can notice at the first time is ring shape. Simple but strong shape set its characteristic.

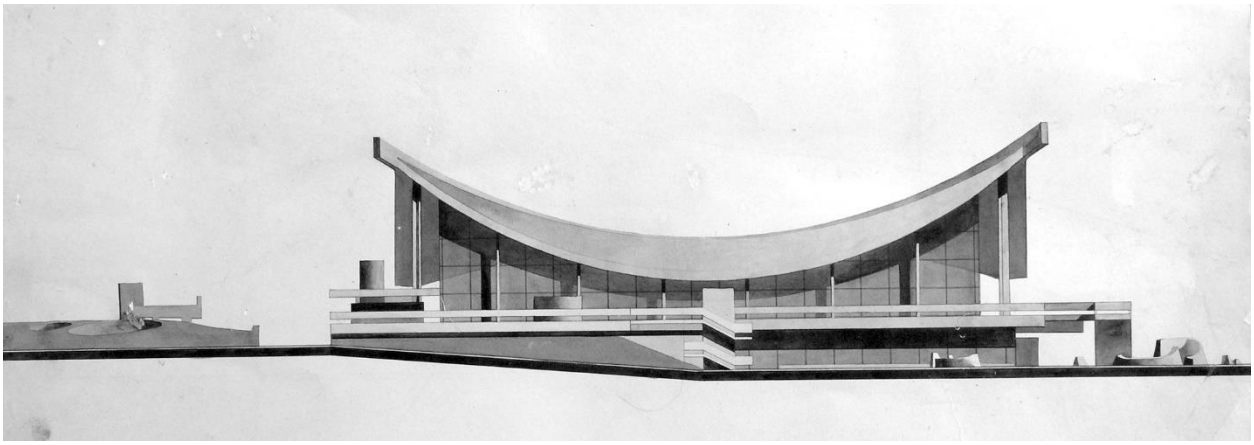


Figure 21The House of furniture (Chmutina Charitable Fund of Architecture and Development, 1970)

The project, the House of the Furniture got double purpose: trade and exhibition. Building was meant to show the Soviet Union's consumerism, and it also contains educational space in it. The one thing that I focus is its structure. The structure of the House of the Furniture is quite experimental one to make the sample of large-span buildings. To make impressive image of the building, strong structure might help.

Figure 22 Ruins of the Buzludzha Monument (Danita Delimont, Getty Images)

The Ruins of the Buzludzha Monument was completed in 1981, this building got meaning which is the birthplace of the socialist movement in Kran. Used to use as an arena held communist party's ceremonies. Now it is abandoned but the impact of the building still strong. That is why so many photographers visit The Ruins of the Buzludzha Monument. The weight of the concrete mass makes people's emotion with awe-of course, that is what propaganda building do. In many ways, I can prefer these methods how to make impact.

The monumental buildings from USSR-Soviet Union-might be disturbing, since its strong and overwhelm figure. However, if architect try to make building with strong emotional impact, these projects are inspiring. Simple material can say more than complicate forms and textures. Like Tadao Ando did, purity of material makes people focus on the building itself.

6 Onkalo Monumental Museum: OMM

Reflecting what I learn from the background and ideas about the Onkalo nuclear waste repository, I propose the Onkalo Monumental Museum-in short, OMM. based on the background study, I designed superstructure with multiple exhibition areas include ideal ‘Seals’ for the Onkalo from now to unpredictable future.

6-1 Concept

GENERAL METHOD: COGNITIVE INTERACTION

To archive the criteria of OMM, what I focused on is the interaction between human emotion and space. Especially cognitive emotional interaction is the main point of OMM. OMM is the building which covers nuclear waste repository and it needed to keep away from outside**. I want to make people uncomfortable when they visit**. Through this, I expect that people realize where they are by themselves. The space itself keep telling the fact that this is not a good place to stay, but not direct way. Which emotional disturbance is most effective? I think anxiety without noticeable source is most effective which can make people uncomfortable. I know my whole tempting in this project sounds awkward, but I think this one also one of possibility of the architecture.

CONCEPT: Anxiety: the place in which you do not want to stay long.

There are spaces which make people uncomfortable. When you encountered some spaces, you might feel that annoying feelings, but you do not realize why. Some architecture suppresses our emotions, some twist our perspectives, and some manipulate our feelings. To make this exotic illogical architecture, I am going to use three methods to make OMM into space which makes people anxious to make them realize themselves that this place is dangerous and irregular.

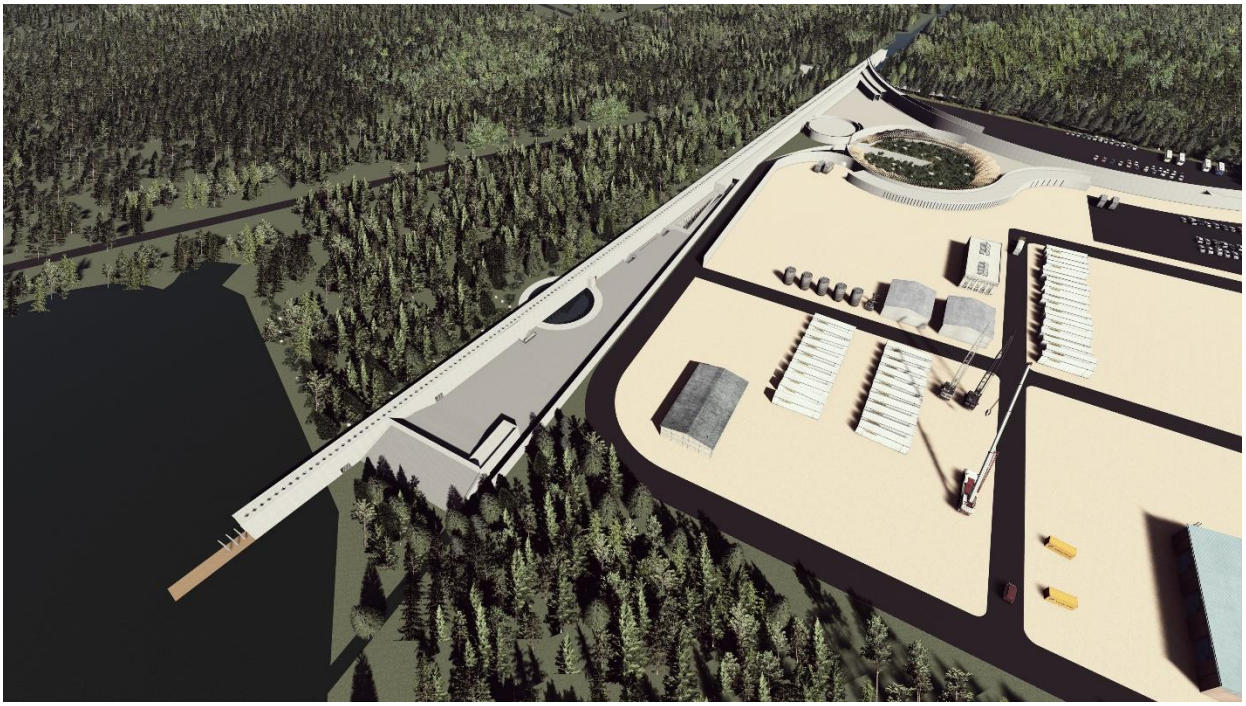


Figure 23 bird view of OMM

6-2 Prerequisites

In this chapter, I will describe the programs of the Onkalo Monumental Museum. When I decided to do my diploma thesis somehow related for the Onkalo, several ideas pop out from my head, such as renovate nuclear plant in Olkiluoto island after its shutdown, co-habitat facility with local residences, building shelter for the Onkalo, dummy facility of the Onkalo for future and so on. What I choose among those ideas is to make monumental public museum for the Onkalo. This is because OMM can be the starting step of all others. I named it for my own purpose OMM-Onkalo Monumental Museum.

The aptness that I think of OMM are follow.

-First, the Onkalo will be needed an architectural facility to support its maintenance, research and education after finishing the storing of nuclear waste. To meet this, **OMM must include research and support facility for the Onkalo**

-Second, Onkalo will be needed multiple layers of protection for possible future incursion. To meet this, **OMM must include 'Seals to keep' to secure the Onkalo from possible incursions.**

-Third, Onkalo will be needed space to enlighten and deliver the information about the Onkalo. To meet this, **OMM must include educational or exhibitive space about nuclear waste repository.**

Whole objectives of OMM to fulfill these demands are mainly by the passive architecture.

Method one: The Sequence

Sequence: storytelling through the steps of spaces is most important part of OMM. The sequence in OMM works in two purposes. First, it represents the life span of Uranium, the fuel of nuclear plant. Representatively, the corridor, there are 235 columns inside and 3 columns outside. It symbolizes Uranium 235 and 238 which are common raw source of nuclear reactor. And its life expectancy is quite long, so long corridor gives the length of time to visitor. And the final part of sequence is the Onkalo, the graveyard of nuclear fuel. Second, entire sequence is long and deserted. Which means, sequence itself can be one of the seal.

Phase1: entrance

Figure 24 OMM car gate

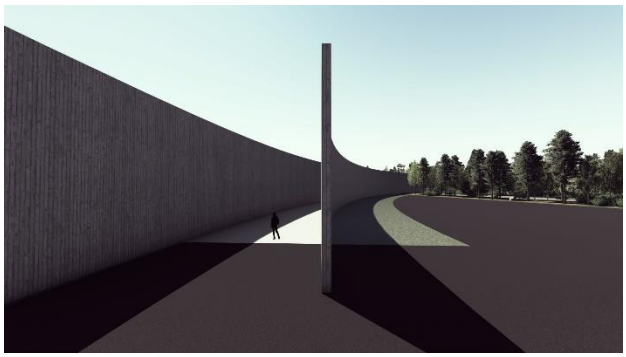


Figure 25 OMM pedestrian entrance

When we visit some museum, things that make impression about building are facade, entrance, and landscape. In my perspective, entrance of OMM need to be empty canvas which means intentionally hide things behind. At the same time, I planned to give cold and empty impression to visitors.

Phase2: corridor

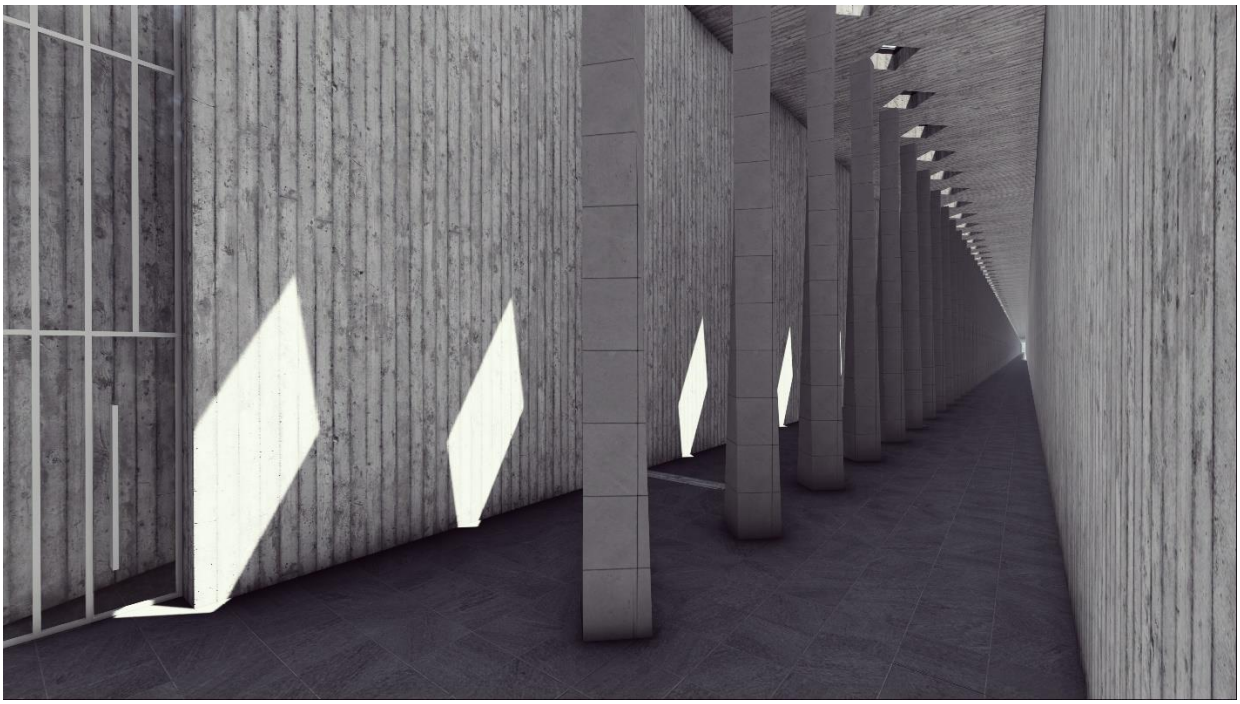


Figure 26 the corridor, from the starting point

People who entered the main corridor of OMM confront massive space which is combination of walls and columns. Walls made with non-human scale height-7 meter- lead visitor's emotion to awe at the first encounter. And ridiculously high and pointy columns make atmosphere more unrealistic. However, after short moments of awe-inspiring time, visitors got anxious since the length of the corridor. There is no sideway or exit but only boundless passage in front of them.

Phase3: hall

About time, visitors will arrive to a huge cylinder shape chamber which placed underground. Place feel nice to visitors, but still this is not a comfortable place. Entire hall situated under the water layer and visitor can see the water on top of them. There will be information why they are under the water. Water is the most effective barrier of radiation but still water can be harm if you submerged. The hall will be the place of the coexistence between threat and shelter.

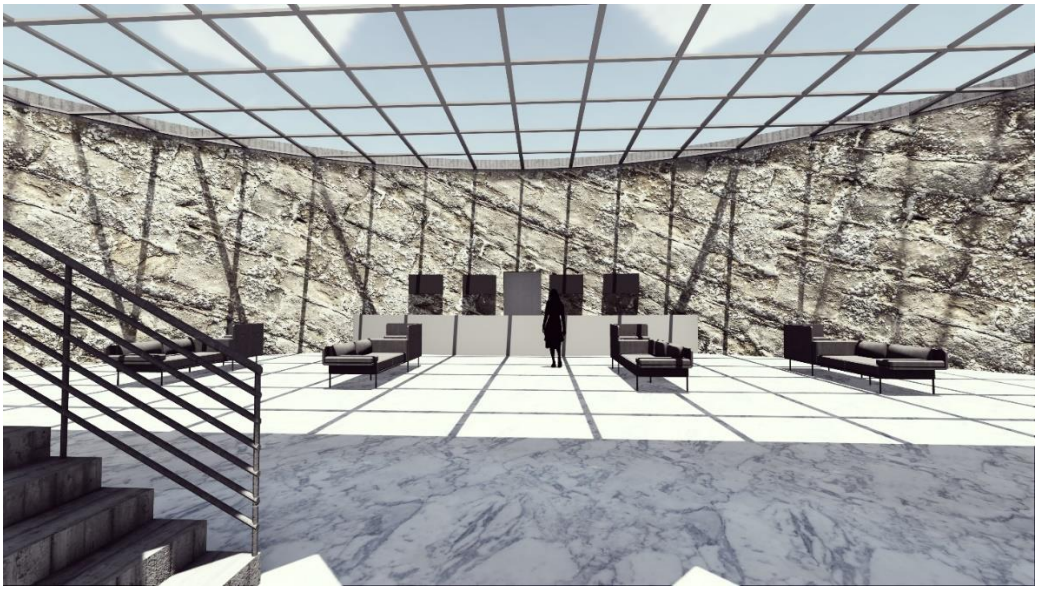


Figure 27 the hall

Figure 28 the hall, view from hall to the corridor level

Phase4: chambers

As a practical exhibiting space, chambers represent physical indirect symbol of rejection to visitors. There are four chambers. First, spike chamber which filled full of spikes and humid mist. Second, wall chamber which exhibiting wall with warning messages. Third, sample chamber which presenting actual container KBS model. And Forth, outside chamber which include cafe and art shop.

Figure 29 spike box

Figure 30 wall box

Phase5: Worm

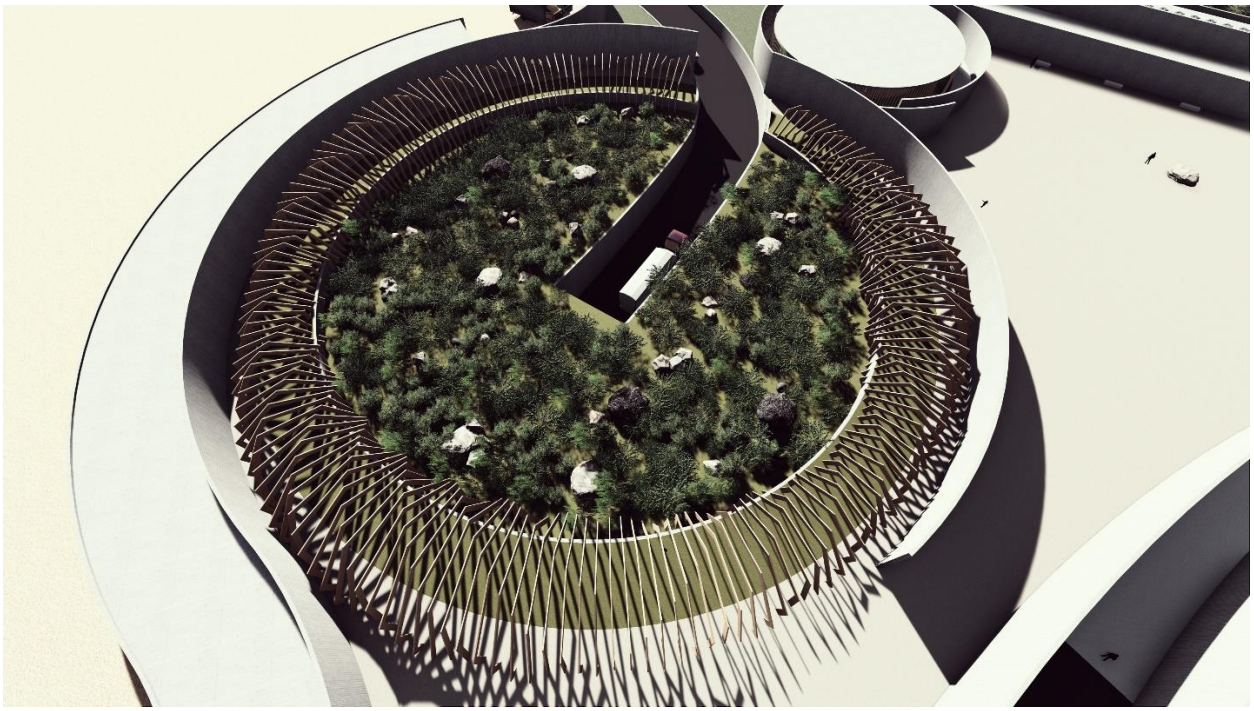


Figure 31 the worm

And final sequence, the worm represents the Onkalo itself. Worm shape wooden structure surrounds the entrance of the Onkalo. Visitors can watch the entrance of Onkalo from a distance. Nothing dangerous happen but put distance a bit to give them feeling that might be risky if you close.

Method two: Symbols

What I expect from using following symbols is enhancing the meaning of sequences.

Monolith: technically, OMM is not a monolith as you can see. Dictionally said, monolith should be upright, but I put the word 'Monolith' cause the symbolic meaning of it. Usually when we refer monolith, it might be geological form, and I think OMM's future form should be like monolith which the building itself represent huge wall and it will changes into geological form. And of course, the columns of main corridor are main monolith of OMM.

Historically monolith means something that treated as an object of worship or respect. In addition, through this behavior, space can make people awe, but also the thing that people can be afraid who not aware of the symbol's true meaning.


Figure 32 left, OMM north end's three outdoor columns, represent the difference between Uranium 235 and Uranium 238.

Figure 33 right, Ululu, a.k.a Earth rock, Australia. Natural geological monolith. (Corey Leopold 2009)

Water: as I mentioned above, water can give multiple meaning to visitors. in normal life, being under the water means death, but in OMM, water represent the barrier and shelter from the radiation.

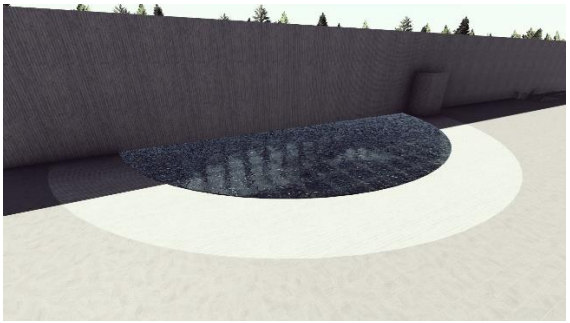
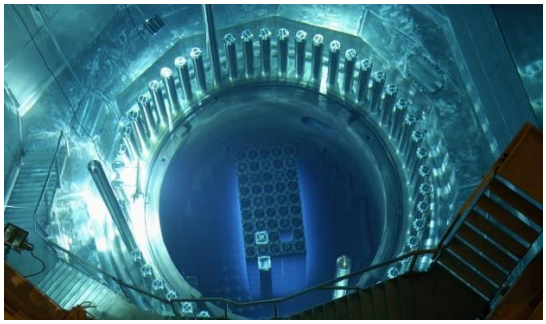



Figure 34 left, OMM water layer of the main hall, it gives submerged experience to visitors.

Figure 35 right. right, Nuclear reactor (Kernkraftwerk Gosgen-Daniken Public Domain)

Moat: from the middle age, the best way to keep building safe from incursion or invasion is separating it physically. Moat is one of the common way to archive this with building castle on the top of the mountain. If the width is enough, it can be presenting strong sign of rejection to every life form except birds.

Figure 36 moat between OMM and Onkalo entering road

Decay: worm like wooden beam structure and wooden frames will decay after hundreds of years. The reason why I use wood for this structure is that this structure should perish away after certain time. I apply wooden structure only two places, outdoor café and structure surrounds the entrance of the Onkalo. This is because, these parts of building should disappear when the lockdown of the Onkalo.

Figure 37 inside view of wooden structure.

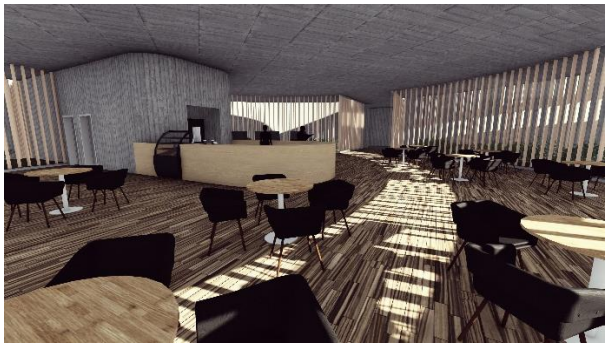


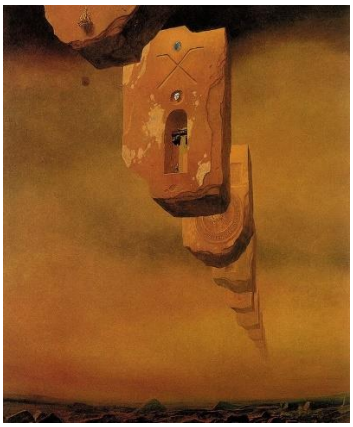
Figure 38 inside view of outside cafe.

Method three: Atmosphere – awe, unpleasantness

Atmosphere is key factor that makes people anxious. Human can get anxiousness with a just small thing. However, many of them are linked with personal experiences. I try to choose three atmospheric factors which might affects in general.

Awe: awe is important stem of OMM's atmosphere. However, the awe in OMM is a bit different kind. We awed when we saw astonishing nature or marvelous structure or amazing performance. However, awe that I try to create is more like feeling that might occurred when we saw grotesque images. Something you aware that is not right but also you can feel amazedness at

the same time. For instance, Zdzisław Beksiński(1929-2005) was hyper realism artist who create grotesque paintings with super scale dimensions. Many of his theme that he used were a bit disturbing or uncomfortable motives but still people who saw Beksinski's work, they felt kind of awe. OMM drags the concept of scale, repeat, and monotone.



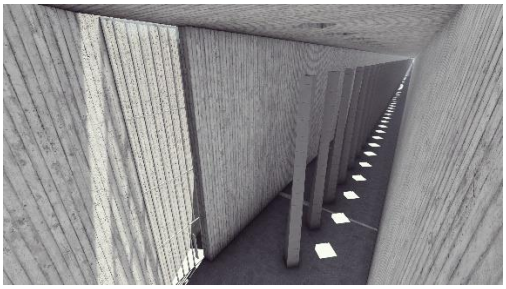


Figure 39 left, untitled (Zdzisław Beksiński n.d)

Figure 40 middle, untitled (Zdzisław Beksiński n.d)

Figure 41 right, corridor in OMM

Humidity: one of the easy way to make people uncomfortable is macro climate. Small changes of macro climate, such as humidity, temperature, and airflow, we can make person's feeling good or bad. Especially slightly high humidity can make people annoying.

Figure 42 Mist in the spike box, warm mist makes the space humid.

Light and shadow: we all have imagination that we cannot control. The thing we called imagination which inherited in our head automatically generate certain beings based on our memory. Best canvas for imagination is light and shadow, particularly when it comes to image that makes people hesitate or anxious since we all be afraid in dark.

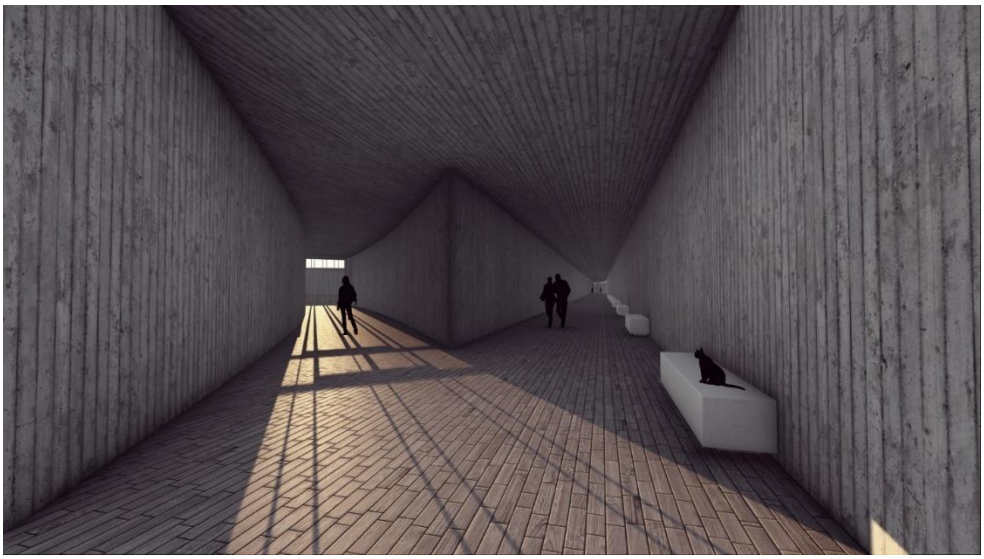


Figure 43 Contrast between light and shadow. OMM's space constantly provides these conflicts along the program of the building.

*For further understanding, I recommend you watch the movie about the sequences in OMM
Movie Link

You can use QR code with your smartphone.

6-3 Diagram

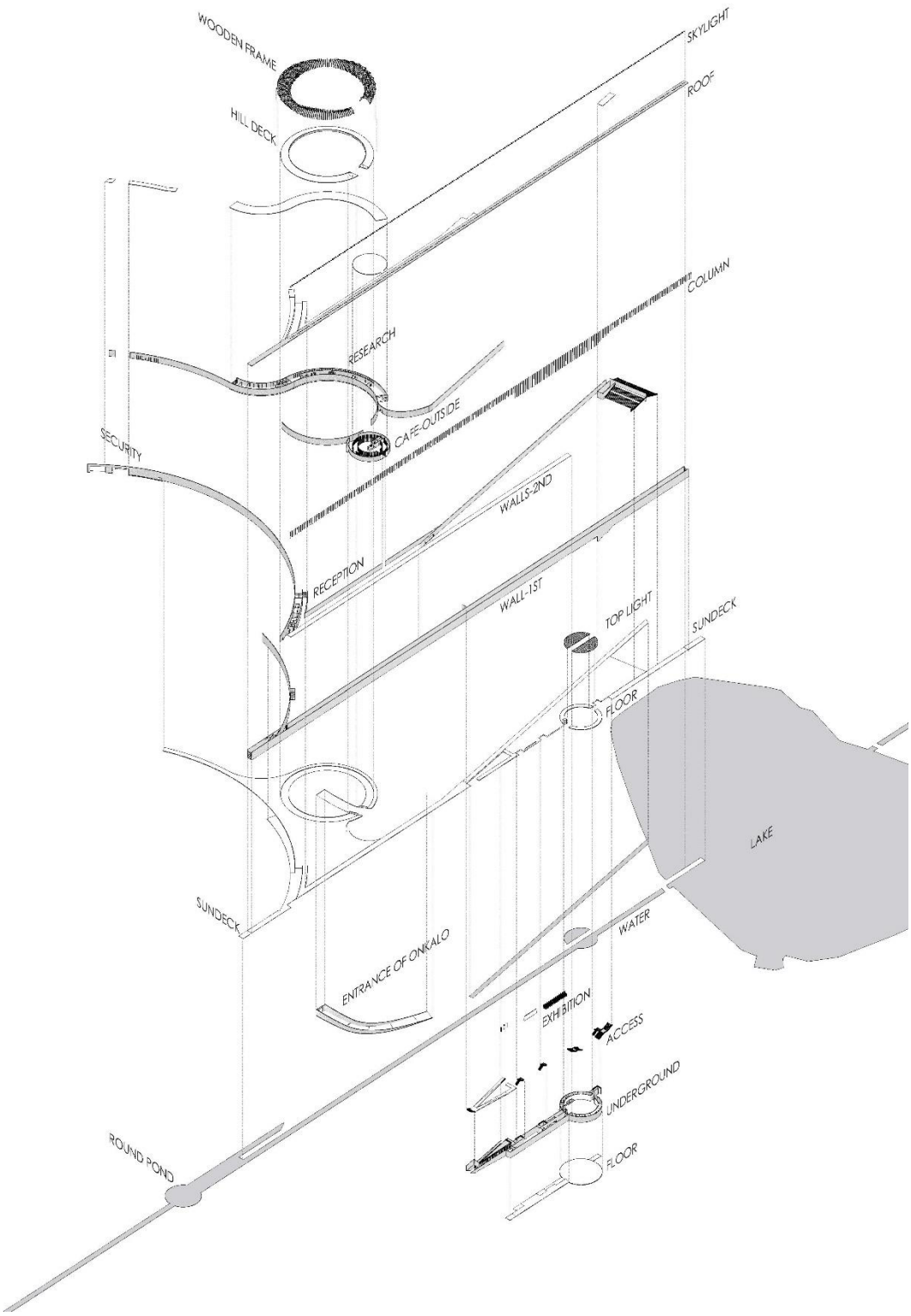


Figure 44 OMM assemble diagram

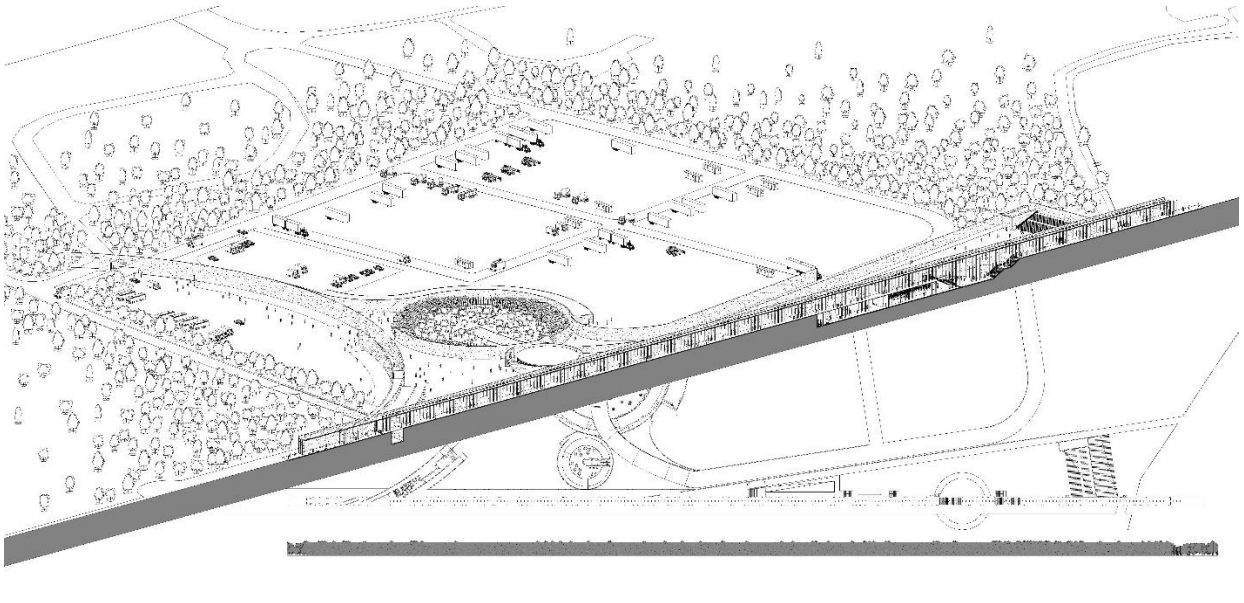


Figure 45 conceptual section, plan, elevation

6-4 Perspectives

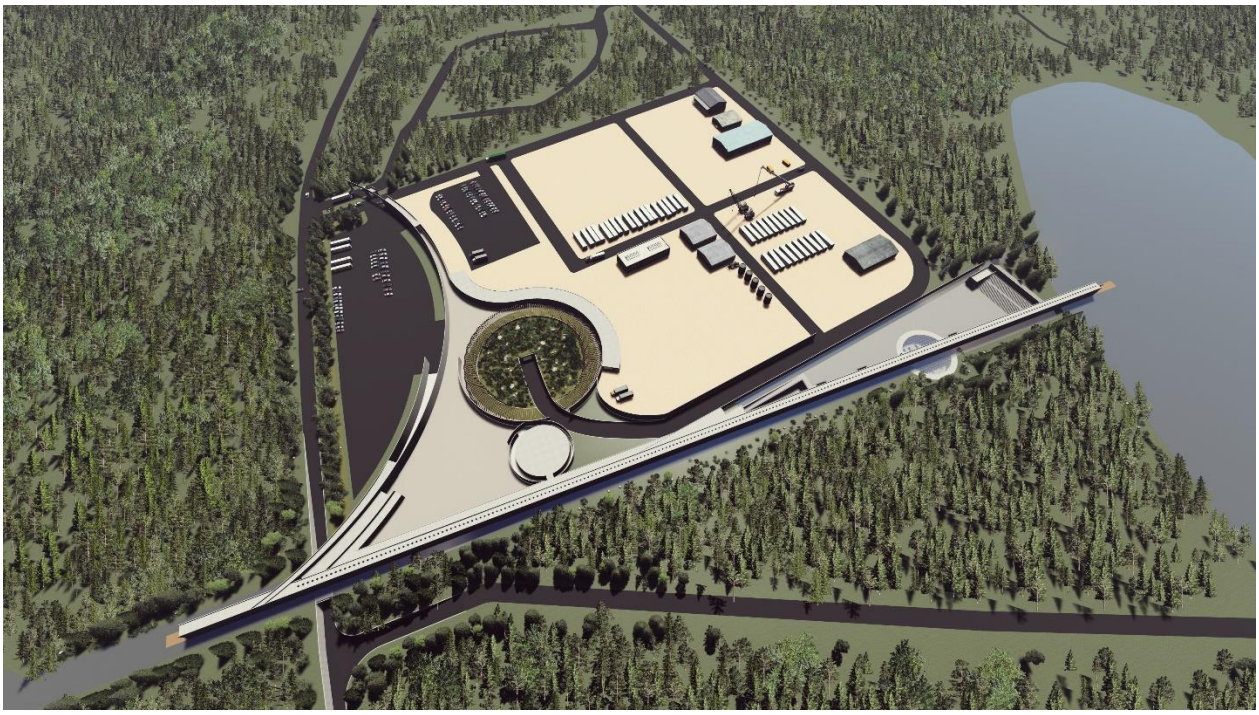


Figure 46 OMM, bird eye from south-east

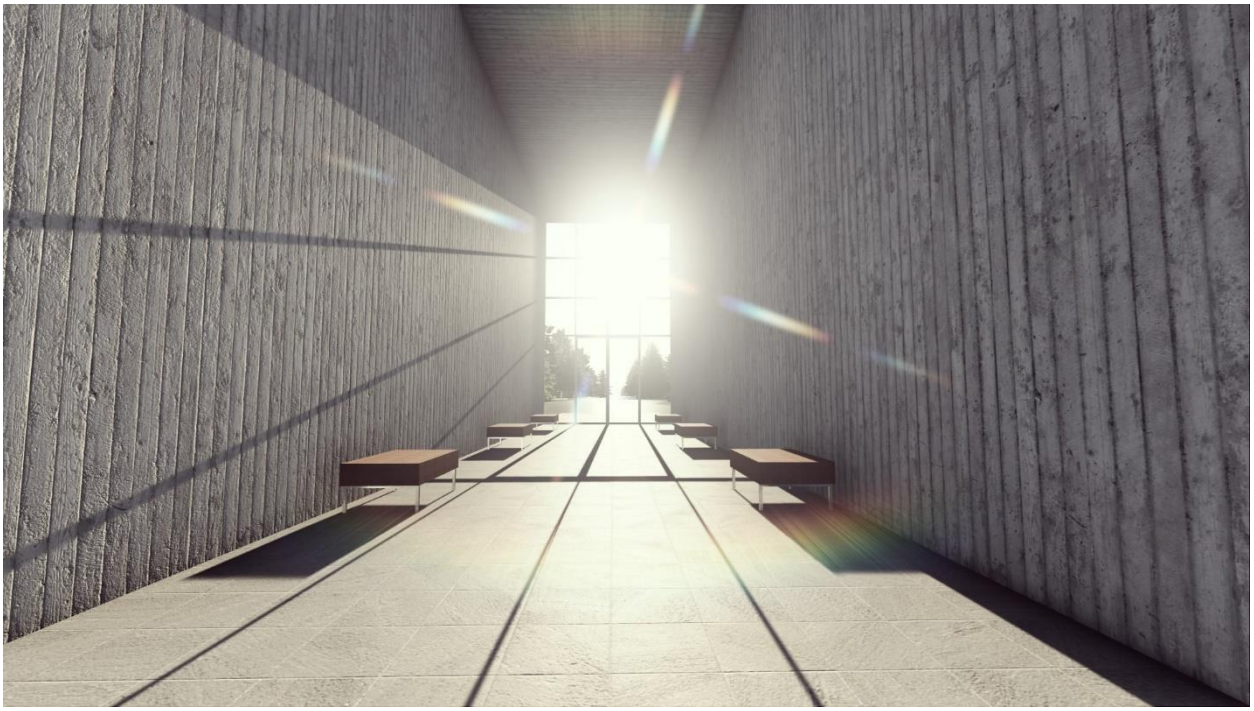


Figure 47 sunroom

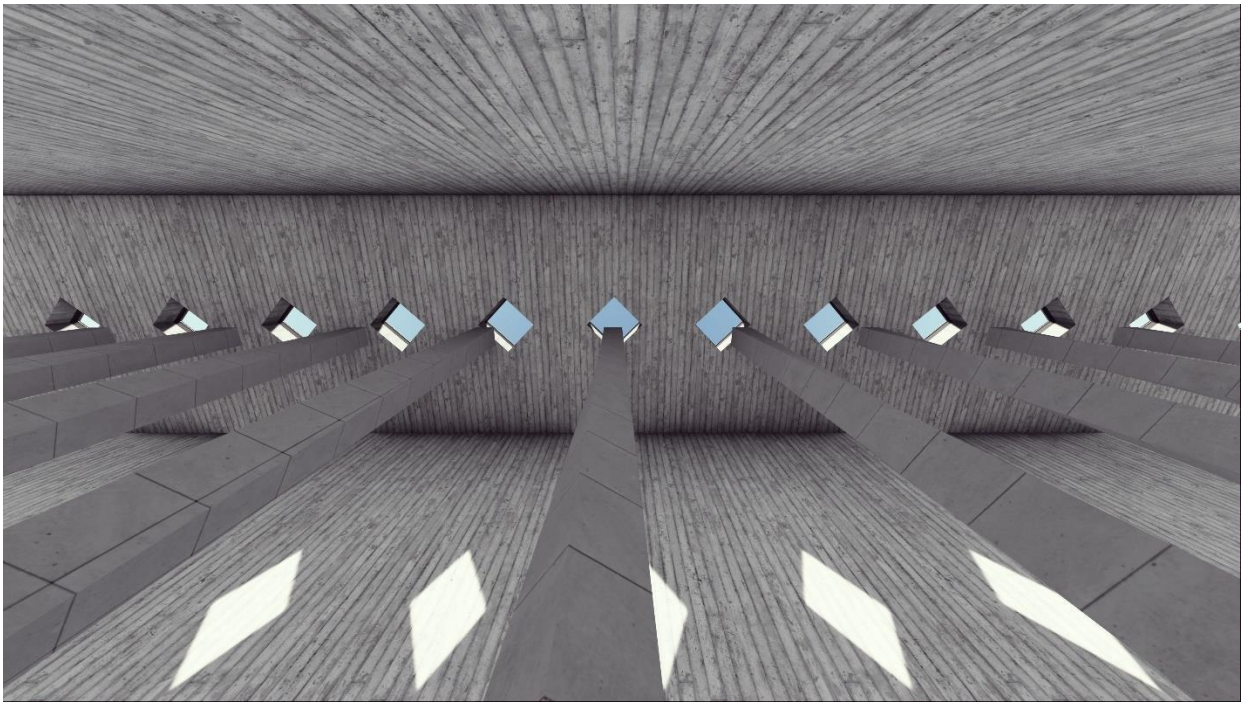


Figure 48 corridor and skylight, view from floor.

Figure 49 tip of columns and skylights, view from ceiling level.

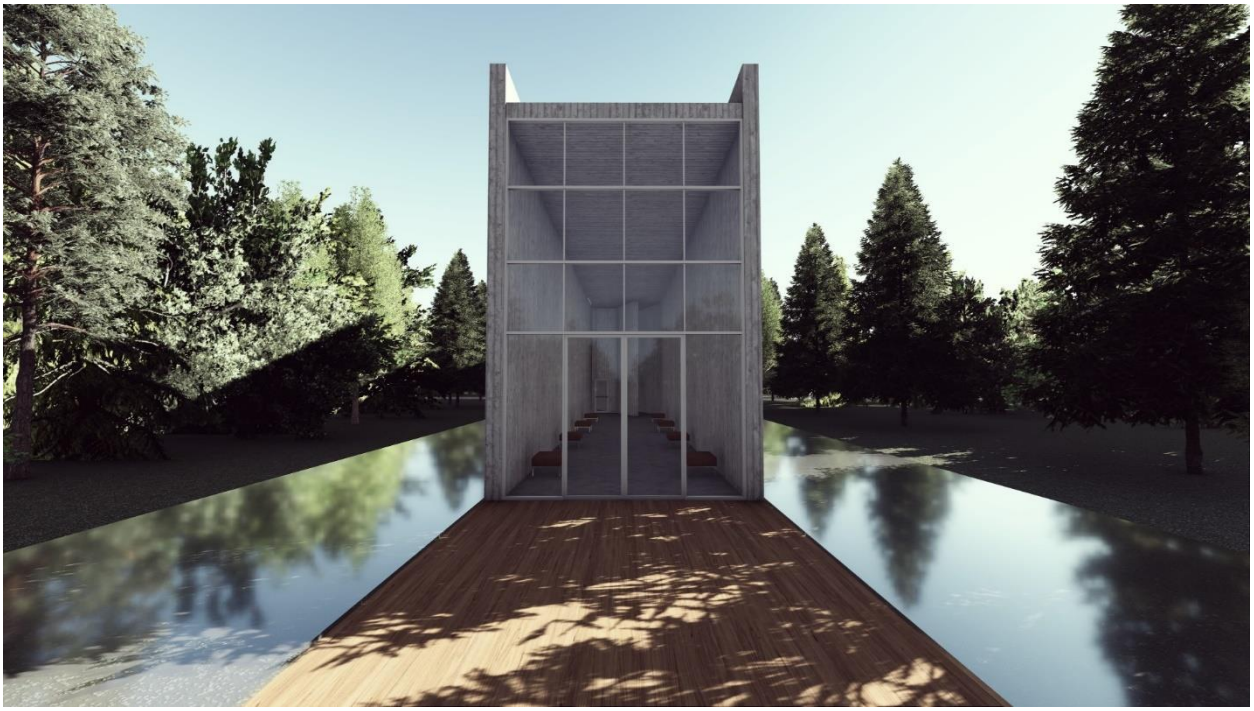


Figure 50 southen edge of building, sundeck.

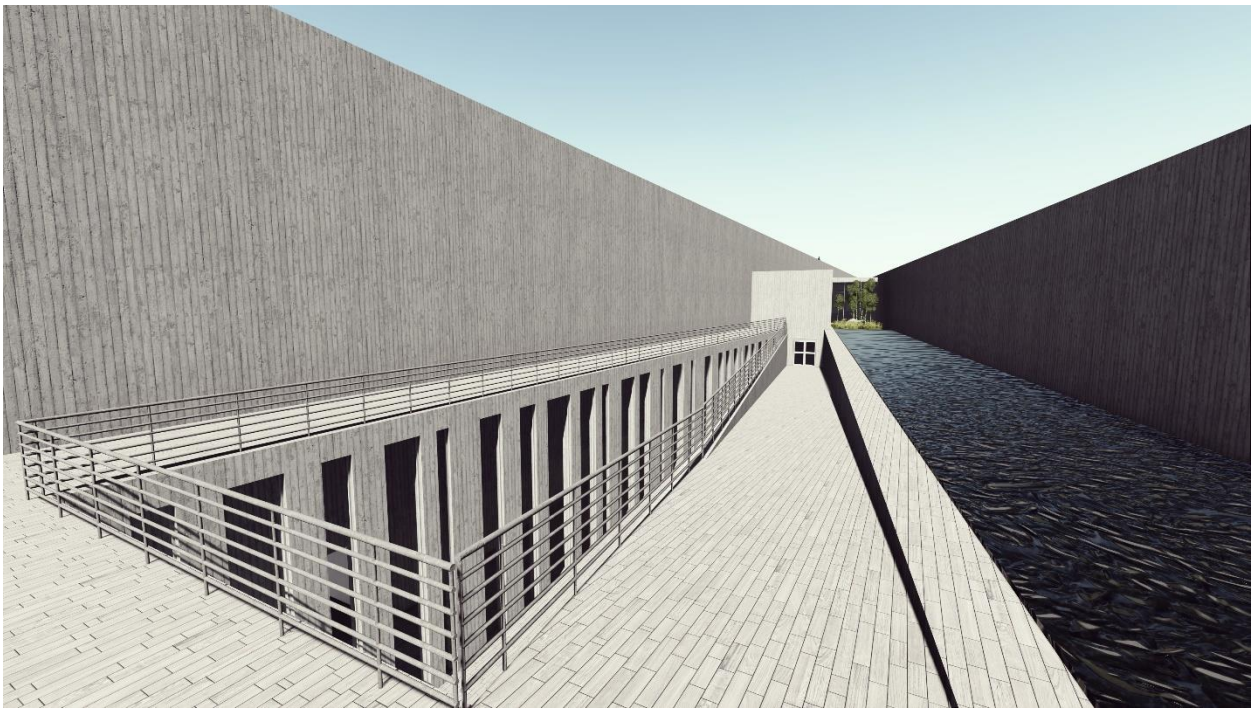


Figure 51 ramp to sample chamber and moat.

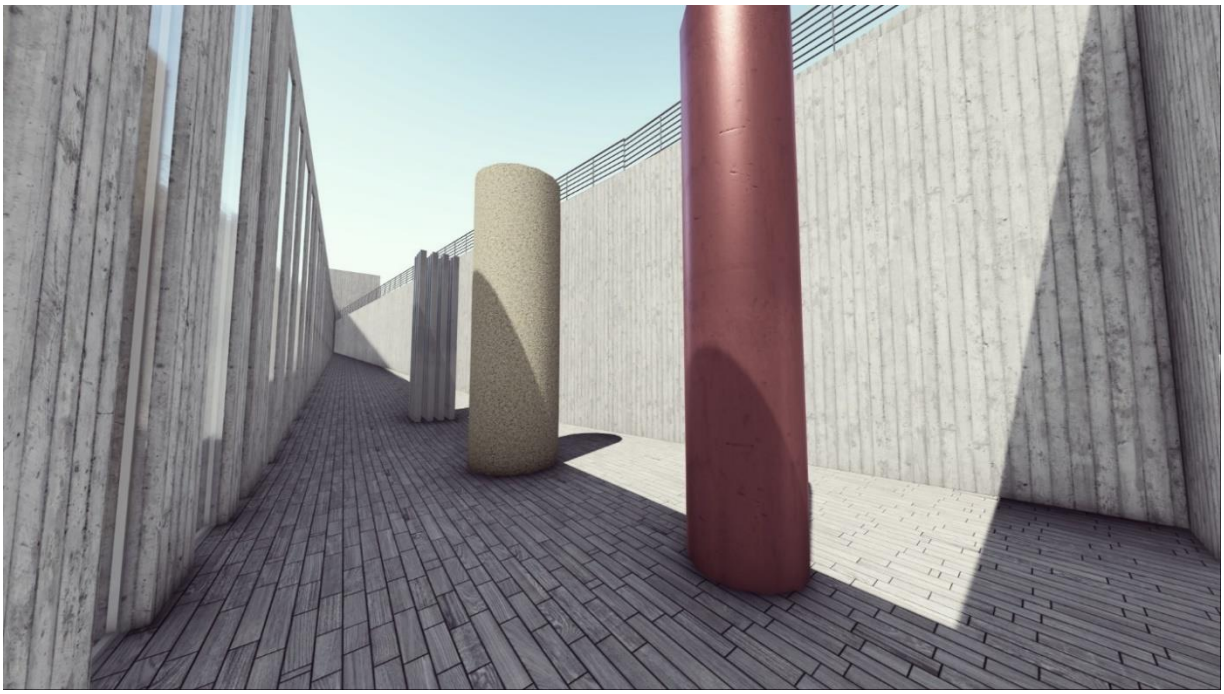


Figure 52 KBS sample in sample chamber. sample chamber is openair space.

Figure 53 sample chamber. view from top

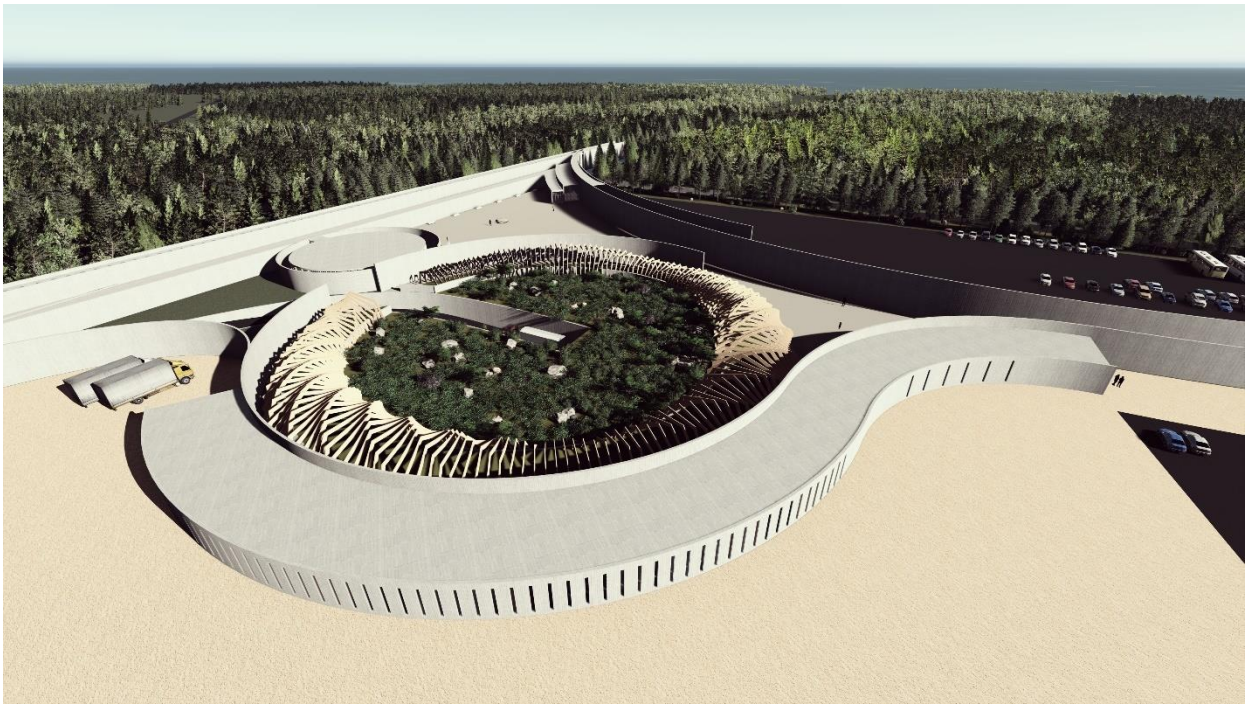


Figure 54 view from north-west.

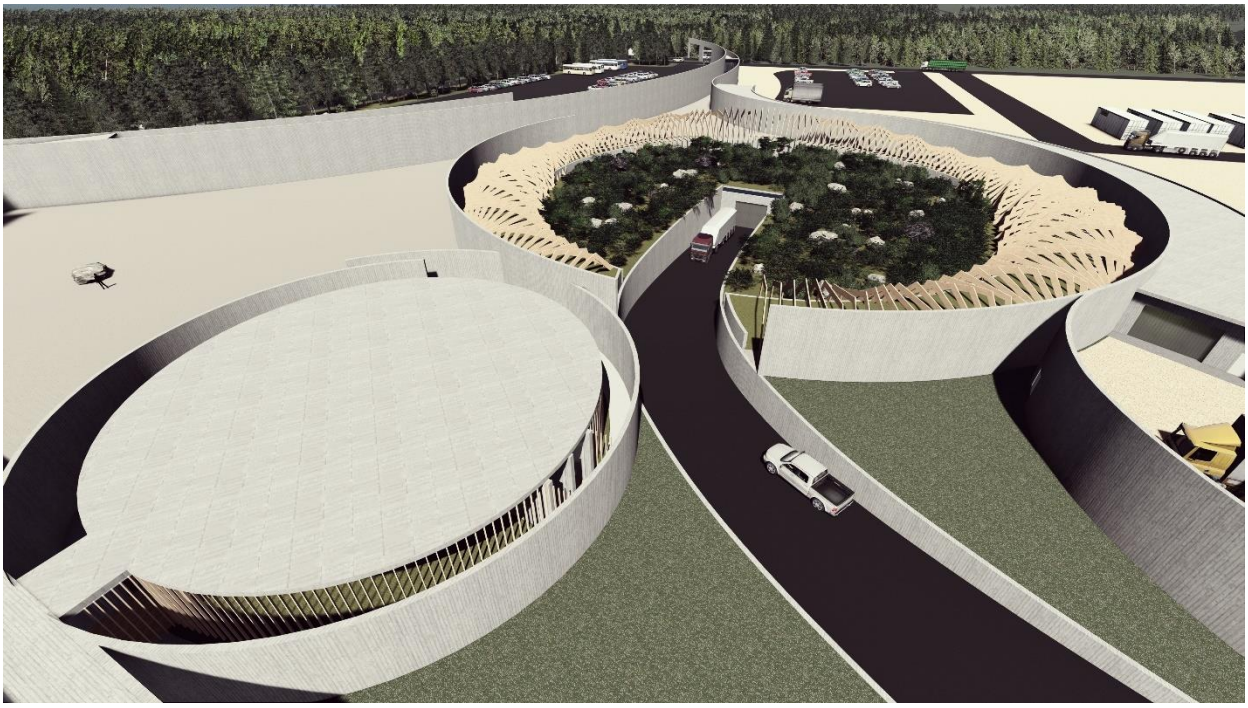


Figure 55 close view of Onkalo entrance. hidden from surroundings.

7 Conclusion

Through the project, there are many things that I learn from it. I been through the philosophy of Finnish government how to deal with historically important topics. The Onkalo is important specimen in this field. And it will be the symbol which spreading the concept of optimistic future. I would say, even though this is not an actual dedication for Onkalo, but still meaningful to propose OMM as an architect.

7-1 Limitations

This is concept proposal and not an actual plan or result of competition. To realize OMM in practices, most crucial part which can be problem is its scale.

To change human's perception towards the place is not an easy task. if the space is long term use purpose like house, the effects can be achieved through multiple times of experiences. However, public space for limited numbers of visits might hard to make huge impact on people's emotion. In case of Tadao Ando, his building's one of the important impact for the people is that it changes the feeling of visitor into deep inner focused states. However, to achieve this, building needs one condition to conduct it with full capability. Length of the time that visitor spent in building is the key of his program. Emotion demands time to get used to new space, and Tadao's long but necessary circulation of architecture provide enough time and space for the emotion. If the circulation is too short, this mechanism's power will decrease or disappear. Reflecting Tadao's practices, I can say OMM's circulation can be effective.

Two major aims of OMM were making the physical rejection for the incursion and the psychological rejection for the incursion at the same time. The length of the building might enough with small scale to cover psychological impact but too achieve physical barrier at the same time, OMM's length was inevitable. There might be more effective solutions to embrace two purposes at once, but in this project, I think this can be the answer.

7-2 Positive results

Still, there is something need to deal with, personally, I learn important lesson. I was in Japan for 6 months for internship and one of the reason why I choose to be in Japan is that in my opinion, Finnish architecture has similarities with Japanese architecture. From cutting edge practicality to deep understanding of wooden materials, and especially for me, I felt that the

philosophy in architecture has connection between them. I had enough good chances to involve world best architect's offices and, I had been visiting countless numbers of amazing Japanese architectures. What got me back in Japan was its high quality of moderation and interactive power of space. I realize that perfectly matched with my idea on OMM idea. OMM is not a perfect concept, but I could implement what I learn from Finnish and Japanese architecture.

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Figures title:

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PANELS

5PAGES

(4 A1 SIZE, 1 CUSTOM SIZE)

OMM
Onkalo Monumental Museum

"We recognized that this could happen. That you might find an open Onkalo. We refer to that as "human intrusion". We don't want this to happen because you may get hurt. But most of all - we are afraid of human intrusion because if Onkalo is opened, the waste will no longer be isolated from all living organisms and we will have failed. In fact, we consider you the main threat to the safety of Onkalo."
– Into Eternity

In Korea-country where I am from- we still arguing for location of nuclear plant because NIMBY problem. We also have nuclear waste repository, but all facilities are temporary one. In addition, these facilities are on the grid and they need continuous attentions of human and resources. In Korea, 30% of energy is coming from nuclear plant and 24 piles are already there. This is 6th largest amount of nuclear piles around the world. However, in terms of treating nuclear waste remains toddler state. I have to say after rapid development during 70s - 90s, Korean government mainly focused on speed and efficiency. And we did focus on mainly on the results, not the residues. Even though, post processing and waste treatment of nuclear resources are immediate affairs, still, these topic's view in Korea is vague.

With my background, for me, the Onkalo project in Finland and all national procedures related with it are shocking. And it drove me to get interested in the Onkalo more. After the days of research for the Onkalo, I realized that still there is no architectural preparation after completion of the Onkalo-of course there will be something, but for now there is any architectural approaches at all. I started to think about the role of architecture in the Onkalo project.

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-Second, Onkalo will be needed multiple layers of protection for possible future incursion. To meet this, OMM must include 'Seals to keep' to secure the Onkalo from possible incursions.

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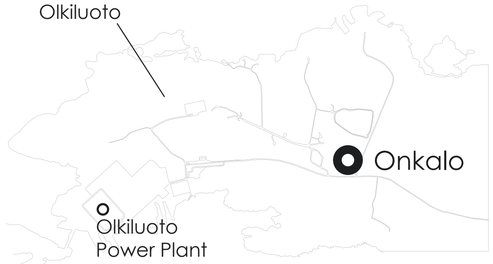
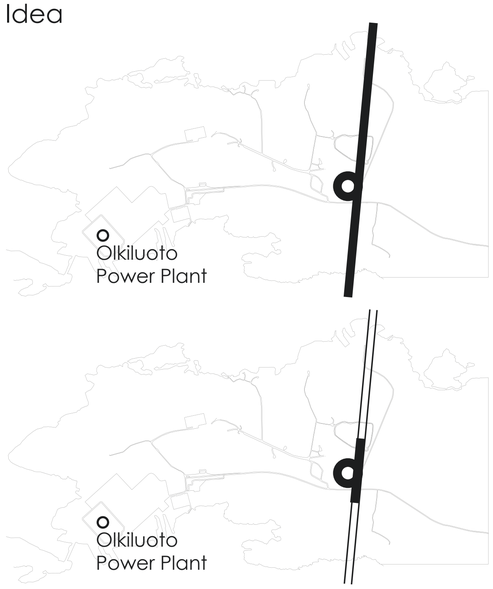
Keywords: Monument, Cognitive, Superstructure, Nuclearwaste

Context



Idea

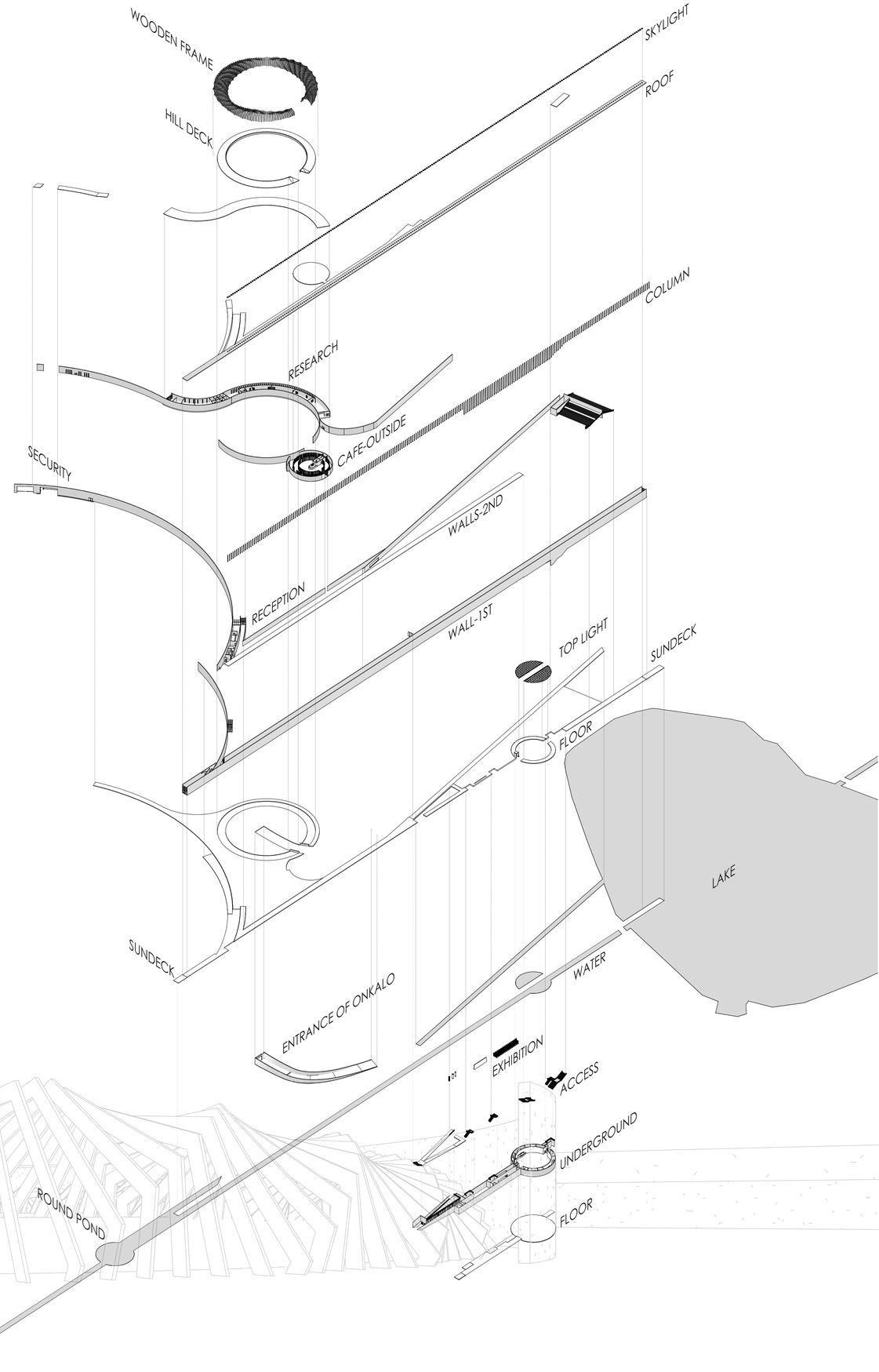


Concept

A N X I E T Y

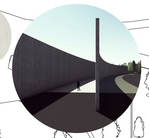
Methods

SEQUENCES
SYMBOLS
ATMOSPHERE

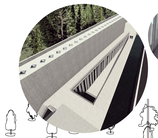
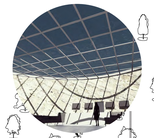


Onkalo Monumental Museum, OMM
SANYUNG LEE, MASTER DIPLOMA THESIS MAY 2018
OULU UNIVERSITY, SCHOOL OF ARCHITECTURE



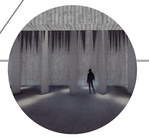

















WATER

SUNDECK 2

WORK SITE 2

WORK SITE 1

WORK SITE 3

WORK SITE 4

SECURITY

PARKING LOT 2

MAIN EXIT

RESEARCH FACILITY

COURTYARD 1

SOLID BED ROCK

SEALS

PARKING LOT1

ONKALO

CAFE

COURTYARD 2

SOLID BED ROCK

SUNDECK 1

Basement Plan
1/500

Ground Floor Plan
1/500

South-East Elevation
1/500

WALL
Wall with the simbol and information, such as warning signs.

SPIKE
Wall with the simbol and information, such as warning signs.

SAMPLE
KBS-3 nuclear waste container sample, copper, pile, and bantonite.

MainCirculation

Outdoor Circulation

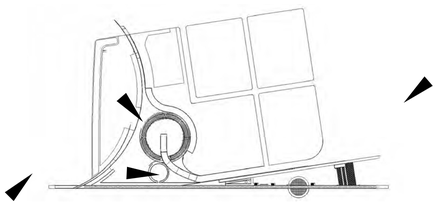
CafeConnection

OMM

CONCEPTUAL SECTION

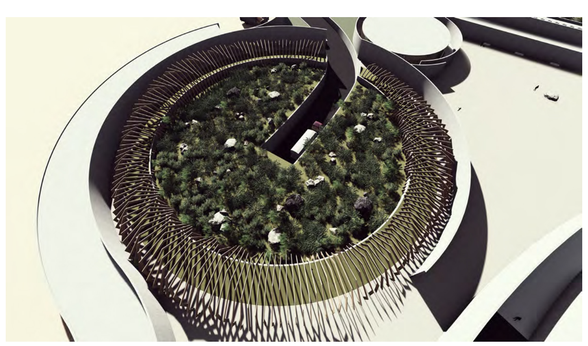
Onkalo Monumental Museum, OMM

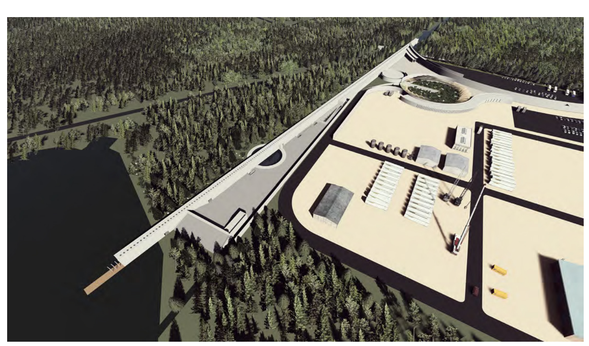
SANYUNG LEE MASTER DIPLOMA THESIS MAY 2018
OULU UNIVERSITY, SCHOOL OF ARCHITECTURE



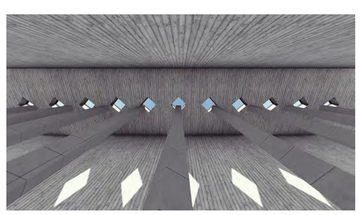
Onkalo Monumental Museum, OMM

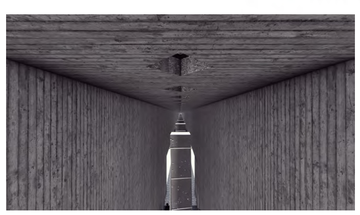
SANYUNG LEE, MASTER DIPLOMA THESIS MAY 2018
OULU UNIVERSITY, SCHOOL OF ARCHITECTURE

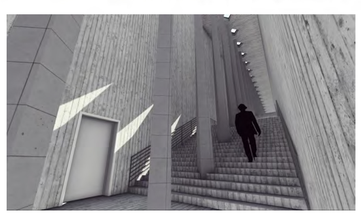




Main Section 1/500

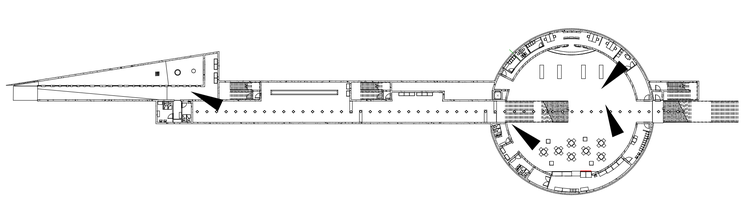






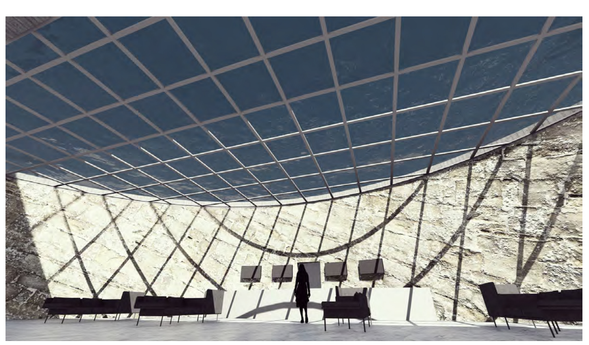
Onkalo Monumental Museum, OMM

SANYUNG LEE, MASTER DIPLOMA THESIS MAY 2018
OULU UNIVERSITY, SCHOOL OF ARCHITECTURE



Onkalo Monumental Museum, OMM

SANYUNG LEE, MASTER DIPLOMA THESIS MAY 2018
OULU UNIVERSITY, SCHOOL OF ARCHITECTURE



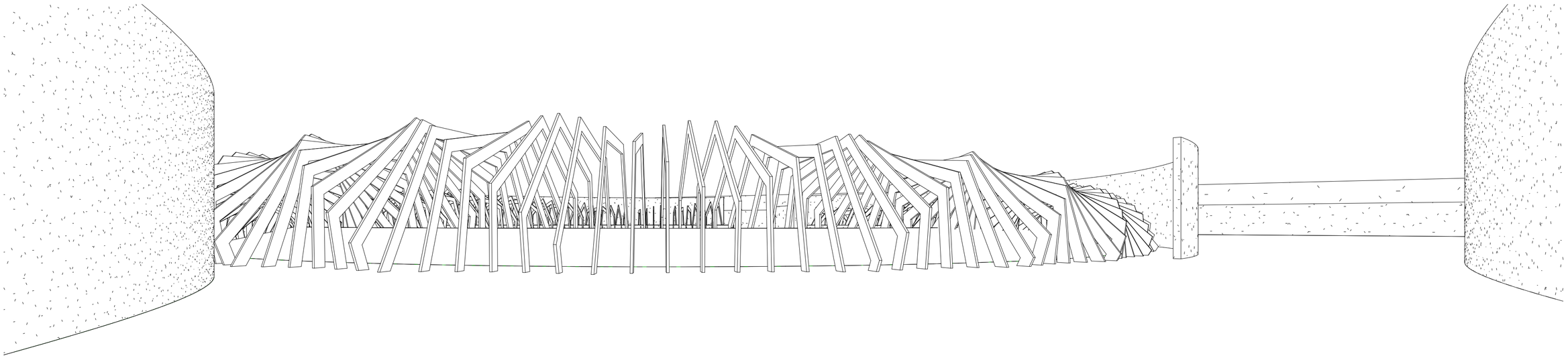
PLANS

20PAGES

O.M.M - Onkalo Monumental Museum - Proposal
SANYUNG LEE

OULU SCHOOL OF ARCHITECTURE,
Master Diploma Project.

May, 2018



CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

OMM - Onkalo Monumental Museum
Finland
COVER

SCALE:

DRAWN: SANYUNG LEE

JOB / DRAWING No. OMM-A101

REVISION

O.M.M - Onkalo Monumental Museum - Proposal
SANYUNG LEE

OULU SCHOOL OF ARCHITECTURE,
Master Diploma Project.

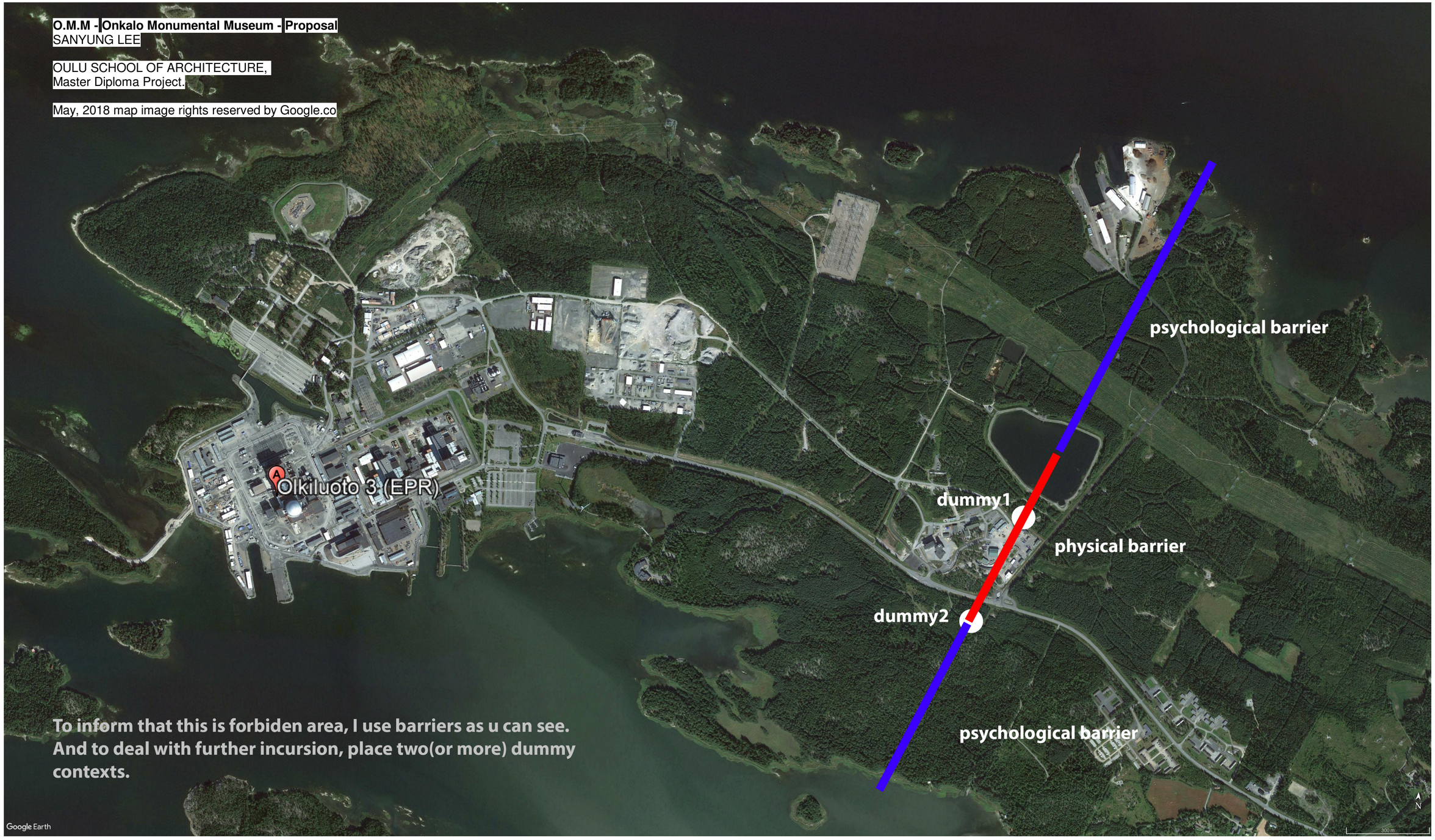
*details will address in the paper which attached with.

Brief: Onkalo is milestone of the treatment for nuclear waste and its repository. it will needs monumental or memorable facility for it. I suggest hte monumental museum for Onkalo. However, I think this museum should not be pleasent place for visitor. I put the concept "anxiety" since I want to give uncomfortable feelings to visitors to make them to feel something wrong about this place-Onkalo. Simply make space with negative effection of cognitive way. Visitor will follow the life cycle of nuclear reacter fuel-Uranium 235- and expect to enlighten themself with this monumental facility.

CLIENT: NONE	Rev. / AMENDMENT / DATE	OMM - Onkalo Monumental Museum Finland Concept	
0 10 20 30 40 50mm PRINT REDUCTION BAR | A3 SHEET		SCALE:	JOB / DRAWING No. OMM-A102
SANYUNG LEE		DRAWN: SANYUNG LEE	REVISION

O.M.M - Onkalo Monumental Museum - Proposal
SANYUNG LEE

OULU SCHOOL OF ARCHITECTURE,
Master Diploma Project.



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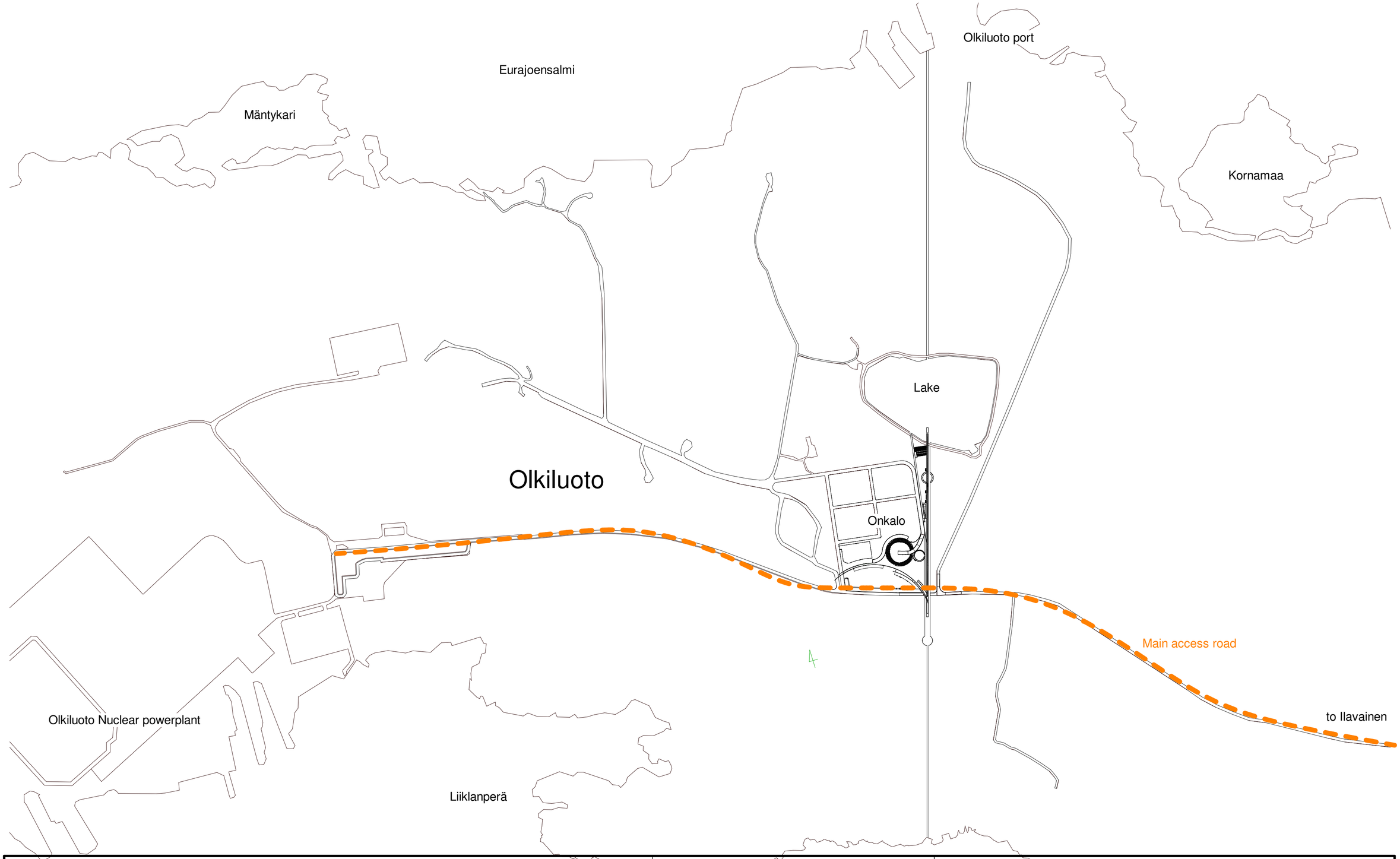
SANYUNG LEE				DRAWN: SANYUNG LEE
				JOB / DRAWING No. OMM-A103 REVISION



CLIENT: NONE	Rev.	AMENDMENT	DATE
0 10 20 30 40 50mm PRINT REDUCTION BAR | A3 SHEET			
SANYUNG LEE			

OMM - Onkalo Monumental Museum
Finland
Context

SCALE: 1 : 10000

DRAWN: SANYUNG LEE

JOB / DRAWING No. OMM-A104

REVISION

CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

OMM - Onkalo Monumental Museum
Finland
Siteplan

SCALE: 1 : 2000

DRAWN: SANYUNG LEE

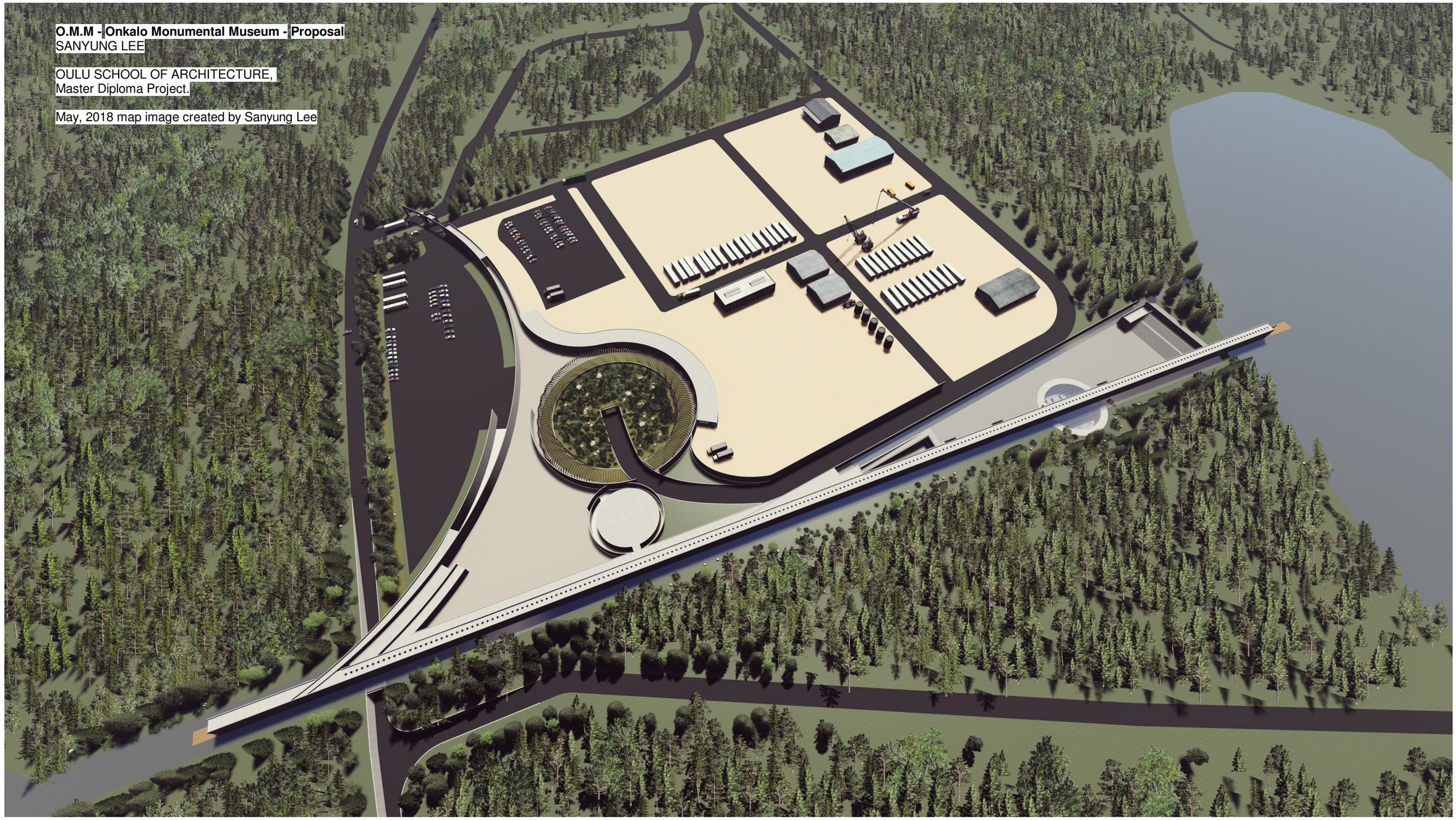
JOB / DRAWING No. OMM-A105

REVISION

O.M.M -|Onkalo Monumental Museum -| Proposal
SANYUNG LEE

OULU SCHOOL OF ARCHITECTURE,
Master Diploma Project.

May, 2018 map image created by Sanyung Lee



CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

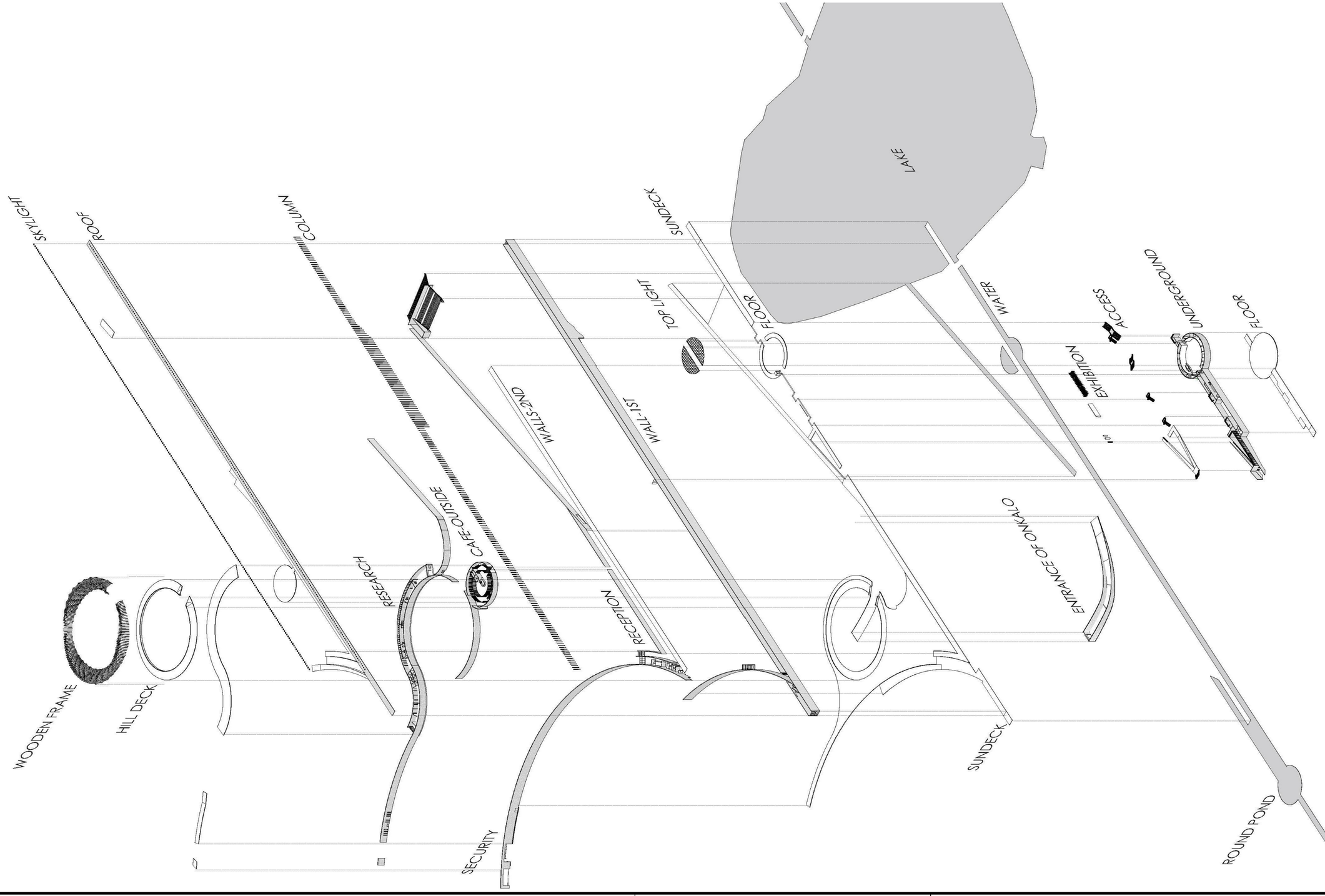
OMM - Onkalo Monumental Museum
Finland
Aerial view

SCALE:

DRAWN: SANYUNG LEE

JOB / DRAWING No. OMM-A106

REVISION



CLIENT: NONE

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PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

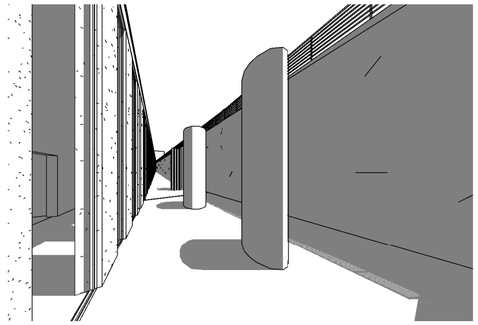
OMM - Onkalo Monumental Museum
Finland
Diagram

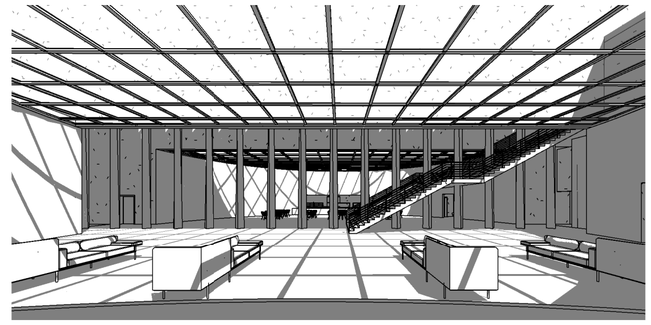
SCALE:

DRAWN: SANYUNG LEE

JOB / DRAWING No. OMM-A107

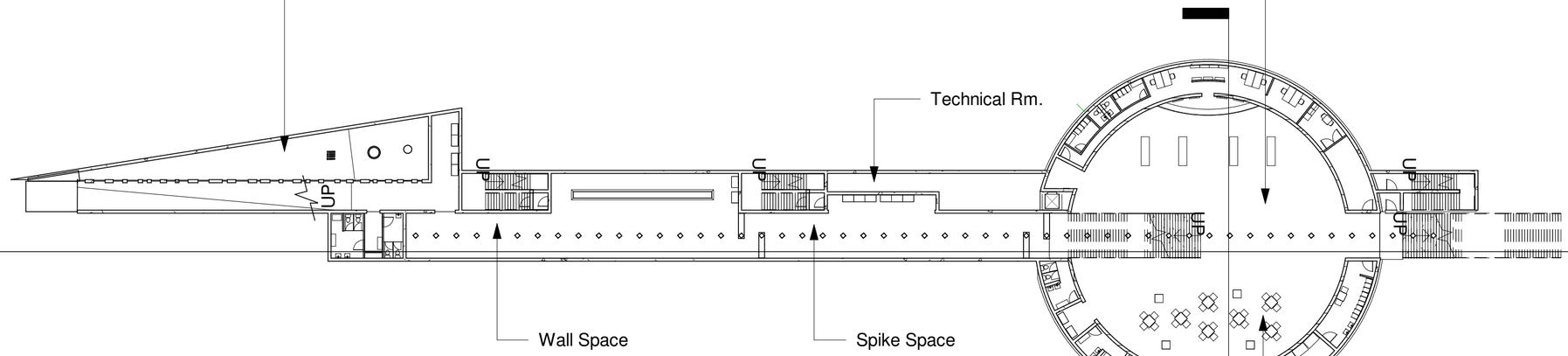
REVISION





Openair Exhibition Area

Main Lobby



Technical Rm.

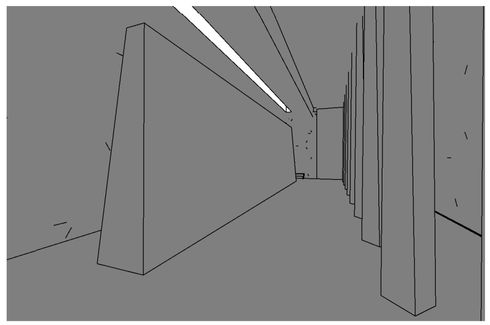
Wall Space

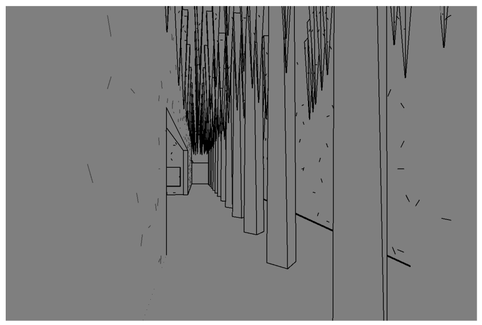
Spike Space

Underground Cafe

3
A117

2
A118





0 5 10 20 30 40 50

GRAPHIC SCALE 1:500

CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

OMM - Onkalo Monumental Museum
Finland
Underground plan

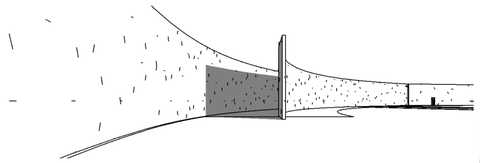
SCALE: 1 : 500

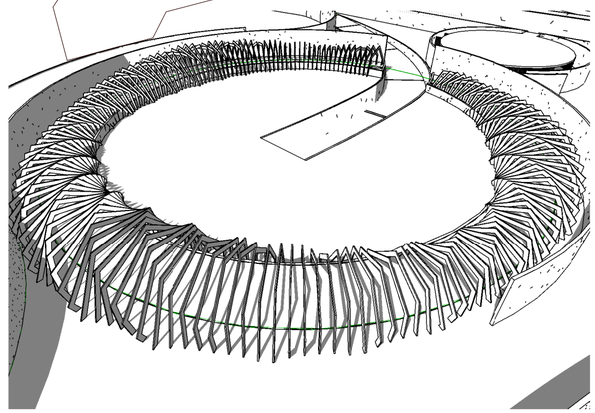
DRAWN: SANYUNG LEE

JOB / DRAWING No. OMM-A108

REVISION

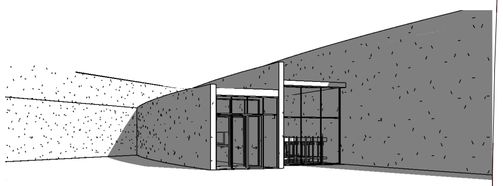
***Since the size gap between basement and ground level, the scale of the ground plan is 1/2000.**
Enlarged plans will follow.



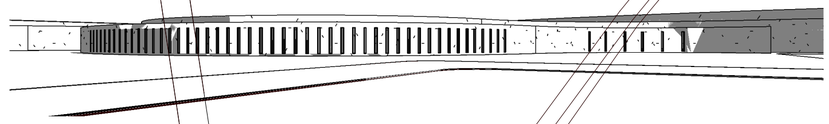


Wooden Structure

Entrance



Exit



Research Facility

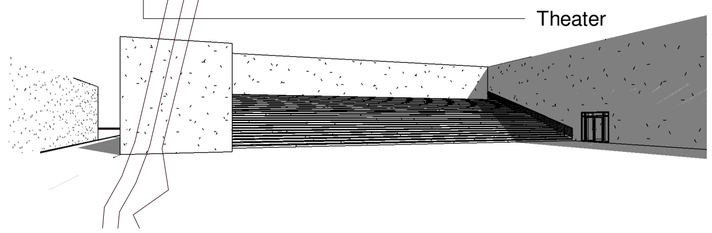
A122 1

A121 2

A122 2

A123 3

Theater



0 10 10 20 100 Metres
GRAPHIC SCALE 1:2000

CLIENT: NONE		Rev. / AMENDMENT / DATE	OMM - Onkalo Monumental Museum Finland Ground Floor Plan
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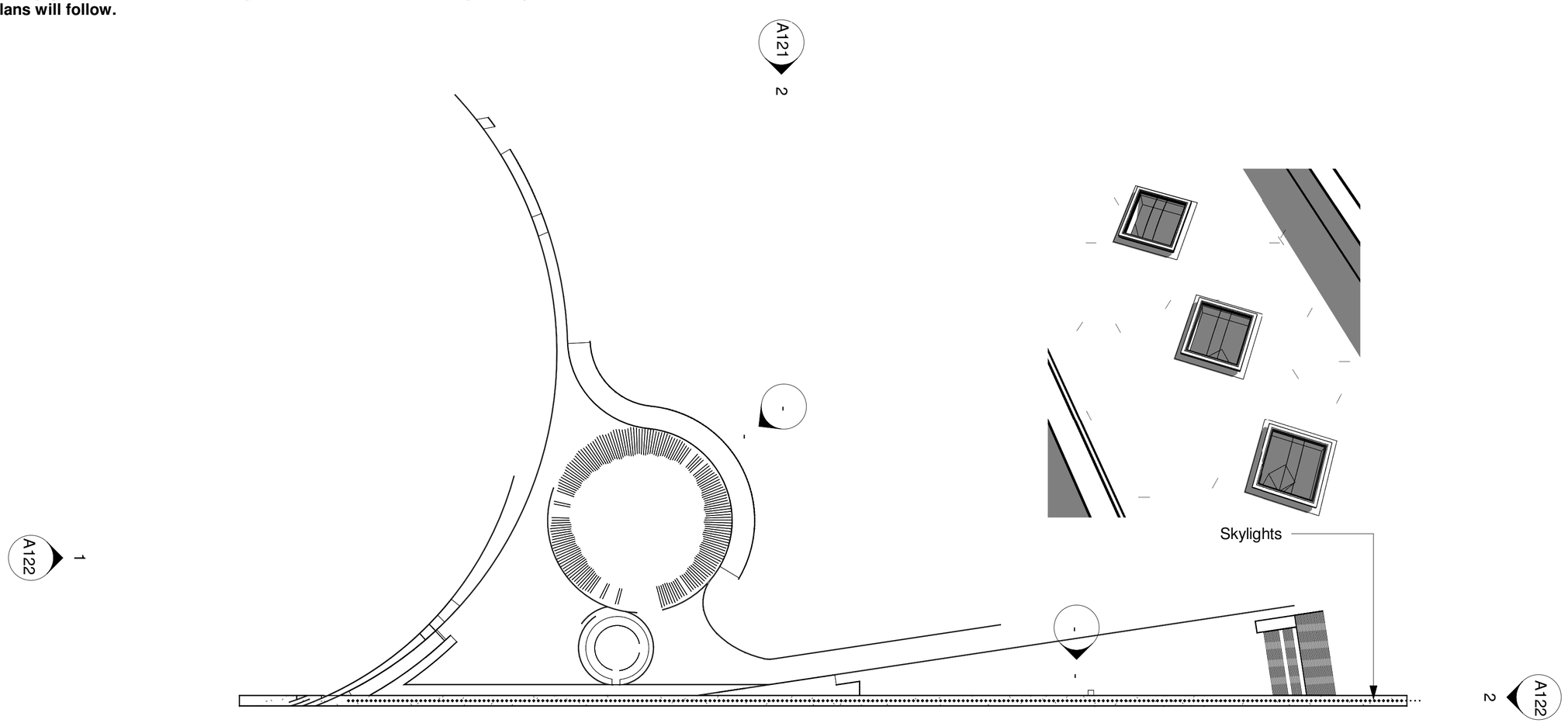
			JOB / DRAWING No. OMM-A109 / REVISION

***Since the size gap between basement and ground level, the scale of the ground plan is 1/2000.**
Enlarged plans will follow.



0 10 10 20 100 Metres
GRAPHIC SCALE 1:2000

CLIENT: NONE	Rev. / AMENDMENT / DATE	OMM - Onkalo Monumental Museum Finland Roof Plan	
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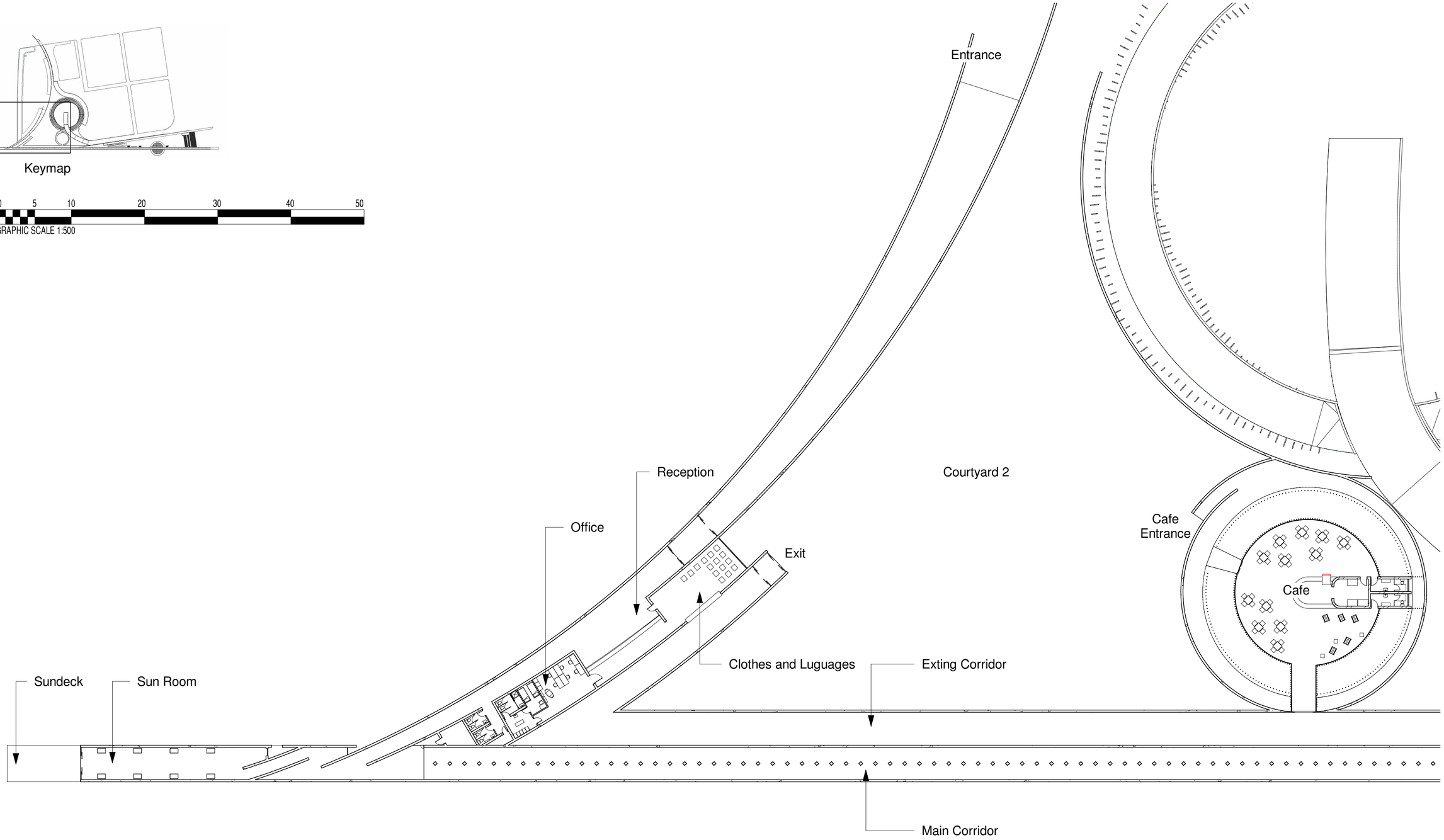
SANYUNG LEE			

Keymap

0 5 10 20 30 40 50

GRAPHIC SCALE 1:500



CLIENT: NONE	Rev. / AMENDMENT / DATE	OMM - Onkalo Monumental Museum Finland Ground Floor Enlarged 1	
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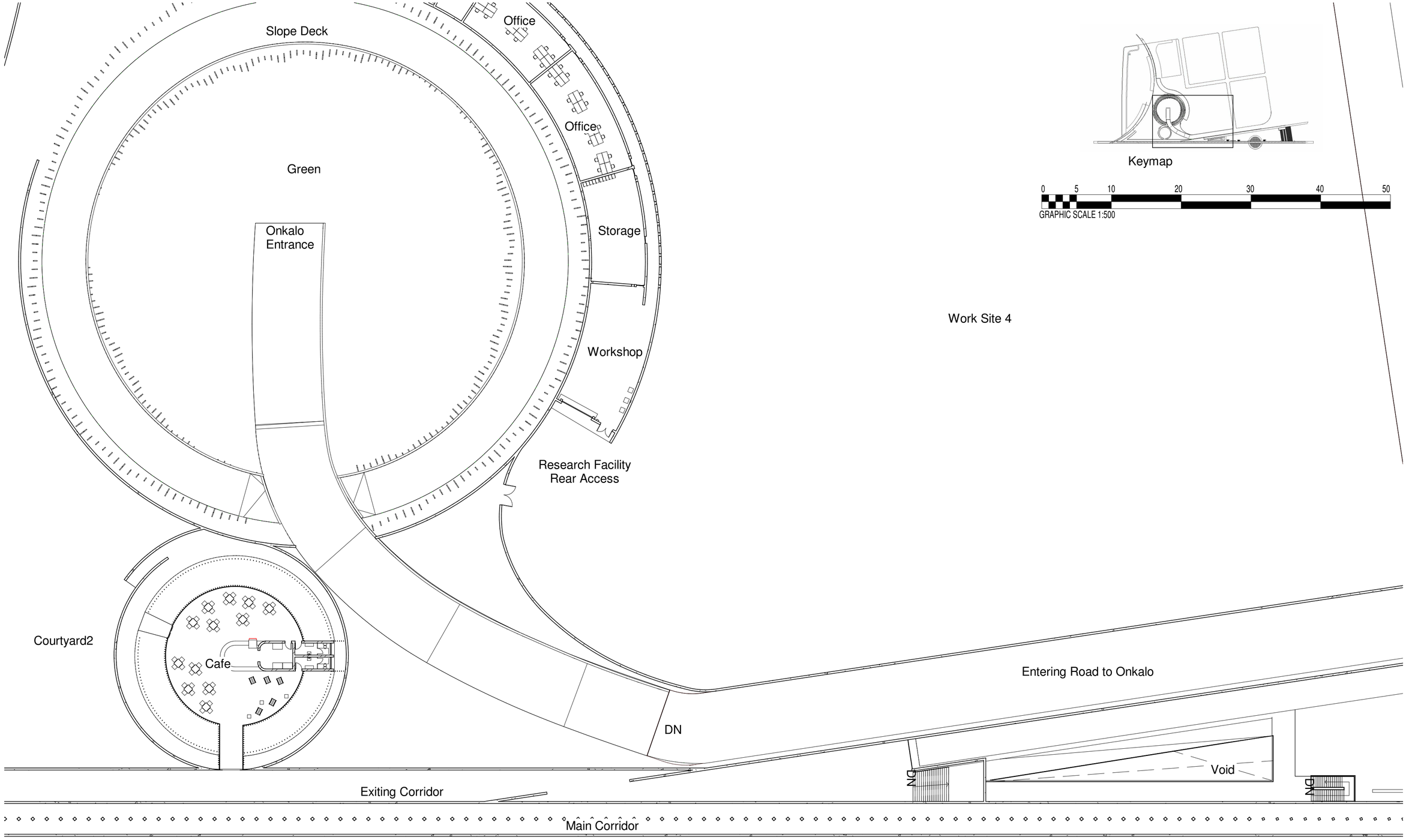
SANYUNG LEE			



Keymap

0 5 10 20 30 40 50

GRAPHIC SCALE 1:500

Work Site 4

CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

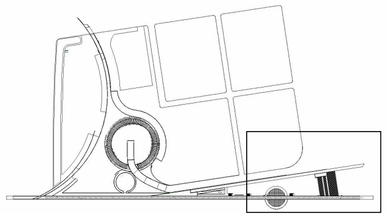
OMM - Onkalo Monumental Museum
Finland
Ground Floor Enlarged 2

SCALE: 1 : 500

DRAWN: SANYUNG LEE

JOB / DRAWING No. OMM-A114

REVISION



Keymap

Work Site3

water

Storage

UP

UP

stand

Courtyard2

Lake

DN

DN

DN

DN

Main corridor

Sundeck

0 5 10 20 30 40 50

GRAPHIC SCALE 1:500

CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

OMM - Onkalo Monumental Museum

Finland

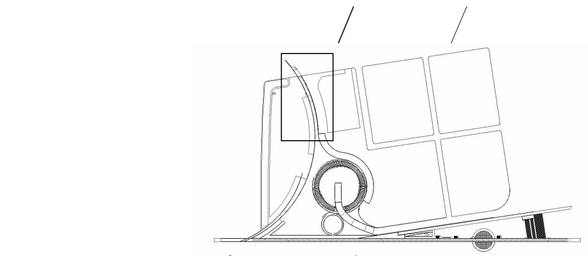
Ground Floor Enlarged 3

SCALE: 1 : 500

DRAWN: SANYUNG LEE

JOB / DRAWING No. OMM-A115

REVISION



Keymap

Security Control

Security Office

Main Exit

Parking Lot

Parking Lot

Main
Entrance

Research
Entrance

Security Line

Security Office

Office

Staff Lounge

Office

Office

Slope Deck

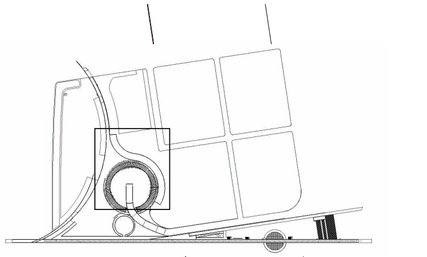
Green

Onkalo
Entrance

Storage

Workshop

Research Facility
Rear Access



Keymap

0 5 10 20 30 40 50

GRAPHIC SCALE 1:500

CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

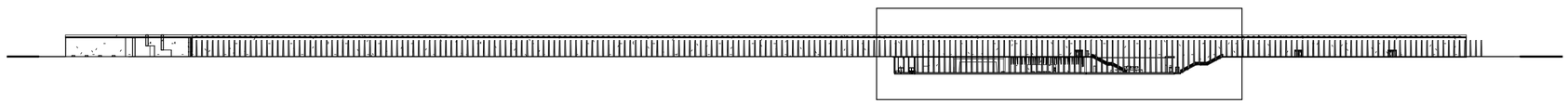
OMM - Onkalo Monumental Museum
Finland
Ground Floor Enlarged4

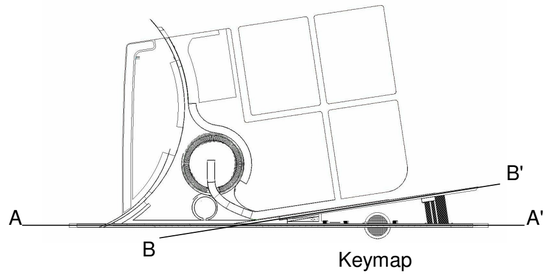
SCALE: 1 : 500

DRAWN: Author

JOB / DRAWING No. OMM-A116

REVISION

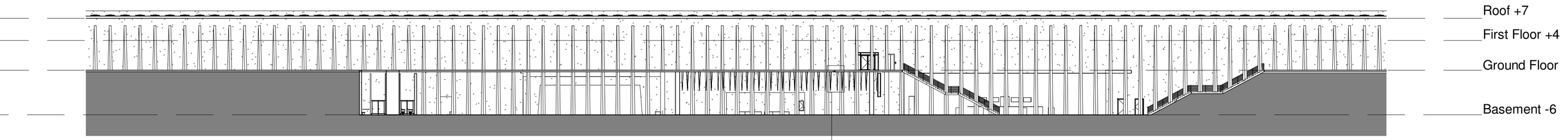




Keymap

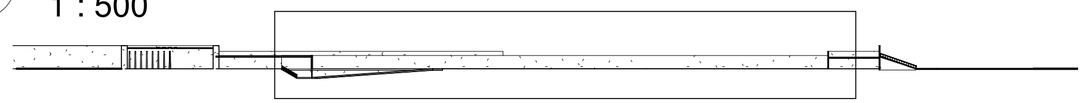
1 Section A-A' LARGE

1 : 2000



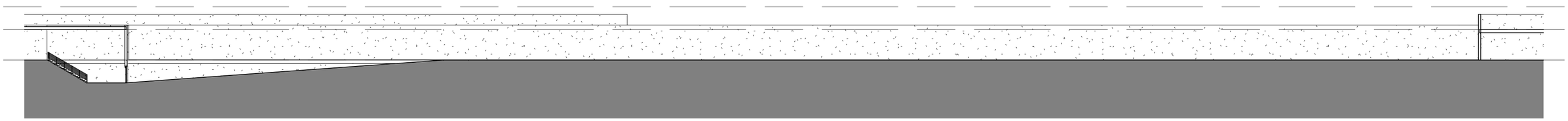
3 Section A-A'

1 : 500



2 Section B-B' LARGE

1 : 2000



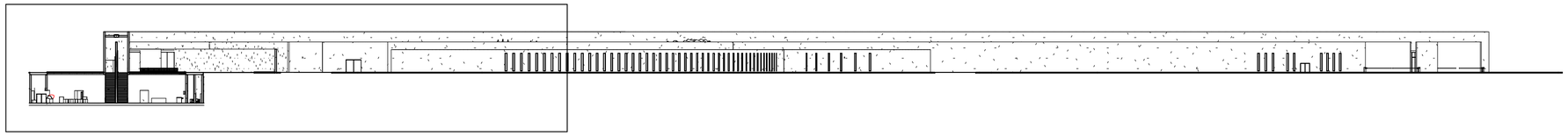
4 Section B-B'

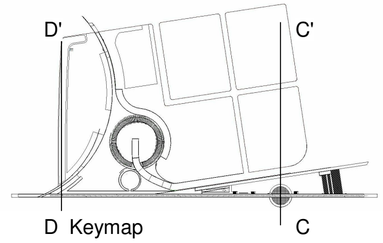
1 : 500

0 5 10 20 30 40 50

GRAPHIC SCALE 1:500

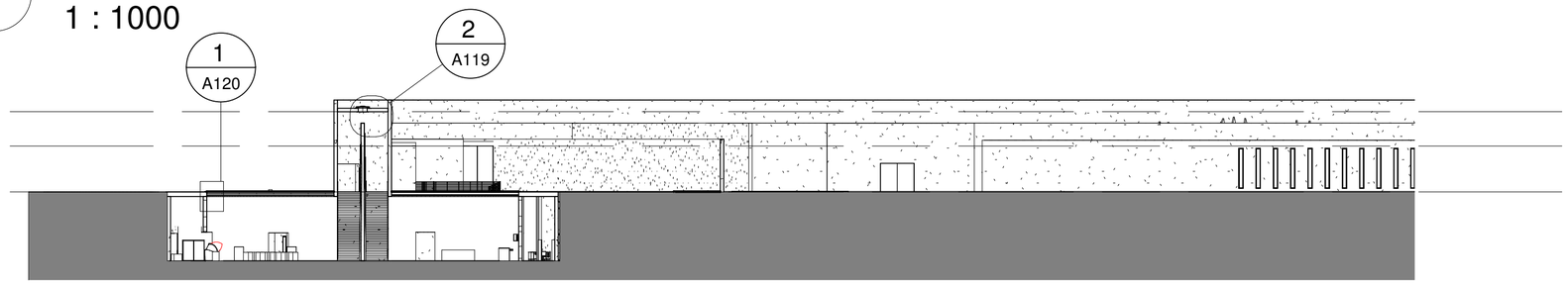
CLIENT: NONE		Rev. / AMENDMENT / DATE	OMM - Onkalo Monumental Museum Finland Section 1
0 10 20 30 40 50mm PRINT REDUCTION BAR | A3 SHEET	*SANYUNG LEE*		SCALE: As indicated DRAWN: SANYUNG LEE JOB / DRAWING No. OMM-A117 REVISION





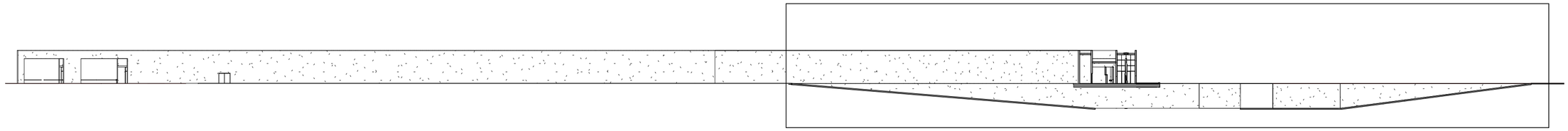
1 Section C-C' LARGE

1 : 1000



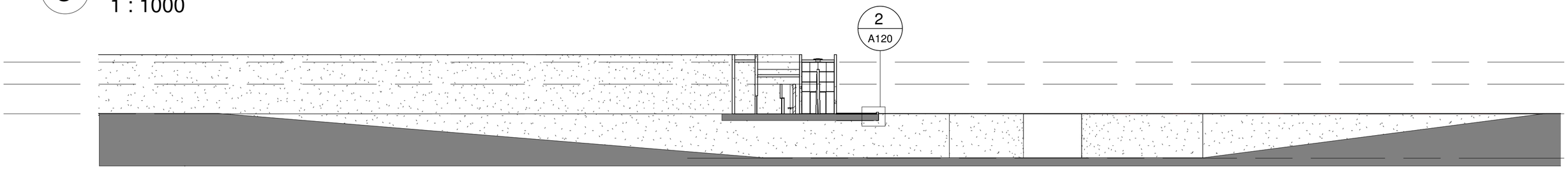
2 Section C-C'

1 : 500



3 Section D-D' LARGE

1 : 1000



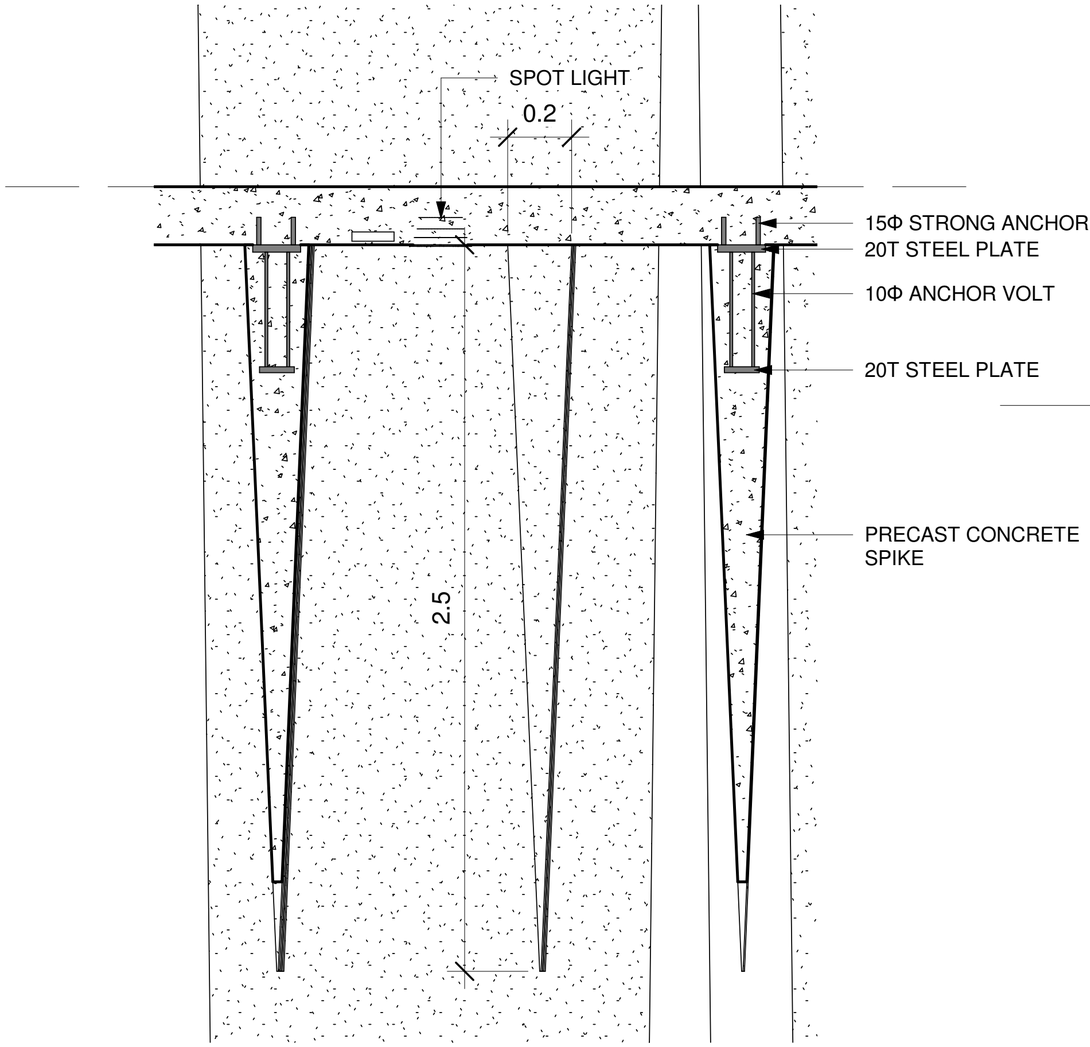
4 Section D-D'

1 : 500

0 5 10 20 30 40 50

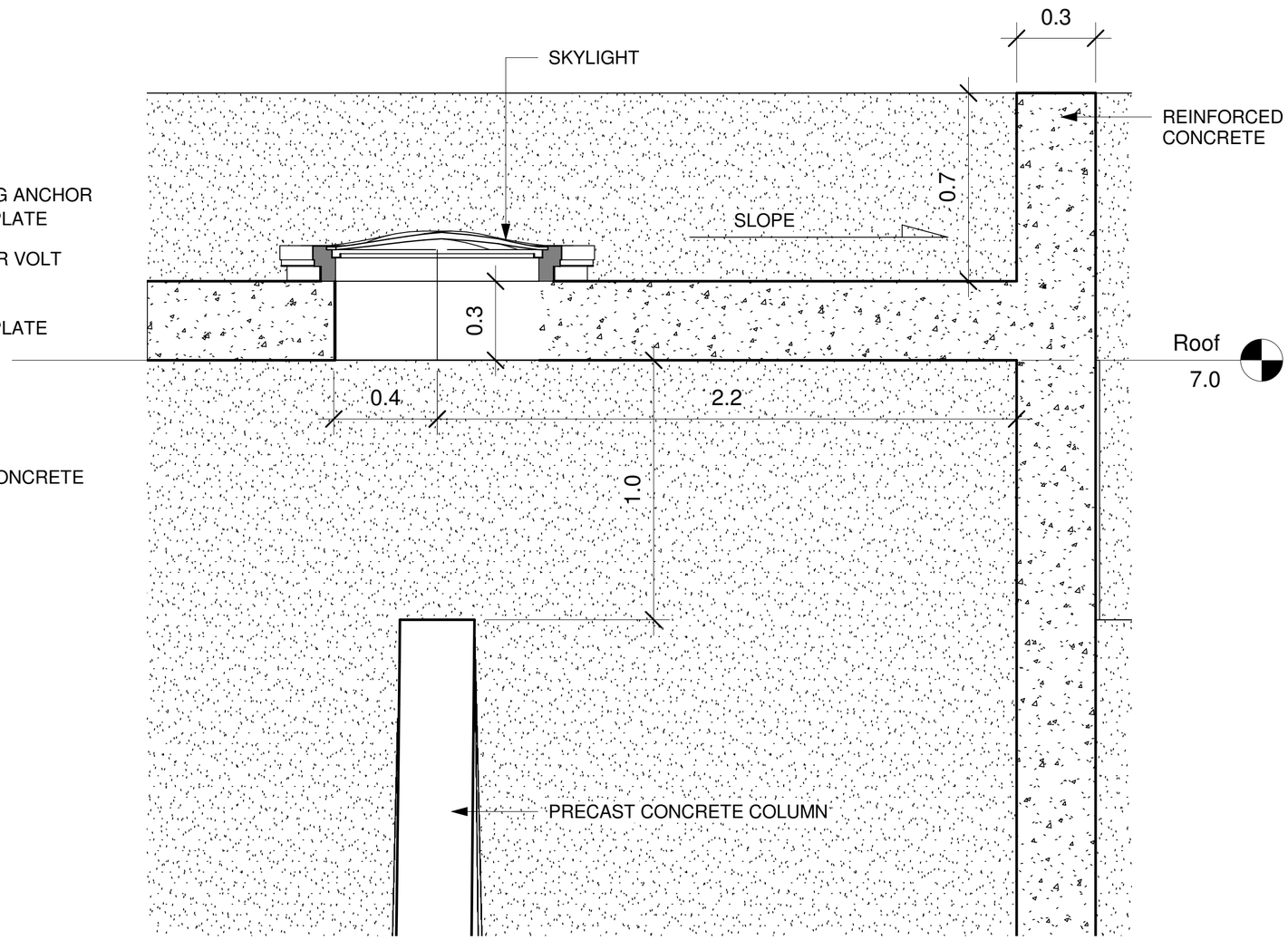
GRAPHIC SCALE 1:500

CLIENT: NONE		Rev. / AMENDMENT / DATE	OMM - Onkalo Monumental Museum Finland Section 2
0 10 20 30 40 50mm PRINT REDUCTION BAR | A3 SHEET	*SANYUNG LEE*		SCALE: As indicated DRAWN: SANYUNG LEE JOB / DRAWING No. OMM-A118 REVISION



1 Section A-A' - Callout 1

1 : 20



2 Section C-C' - Callout 1

1 : 20

CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

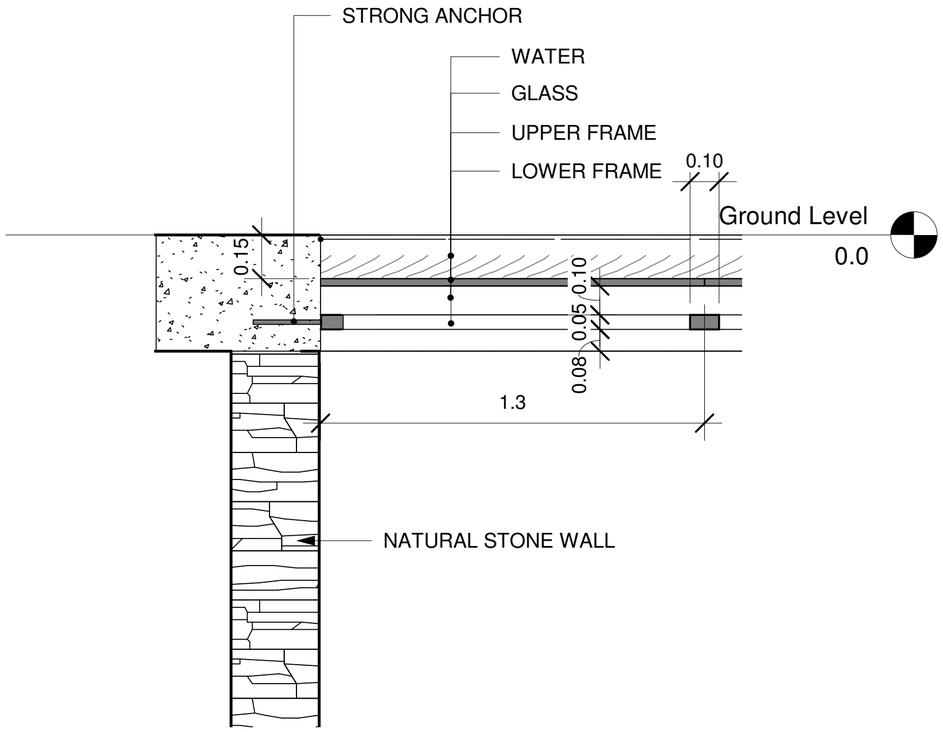
OMM - Onkalo Monumental Museum
Finland
Section Detail 1

SCALE: 1 : 20

DRAWN: SANYUNG LEE

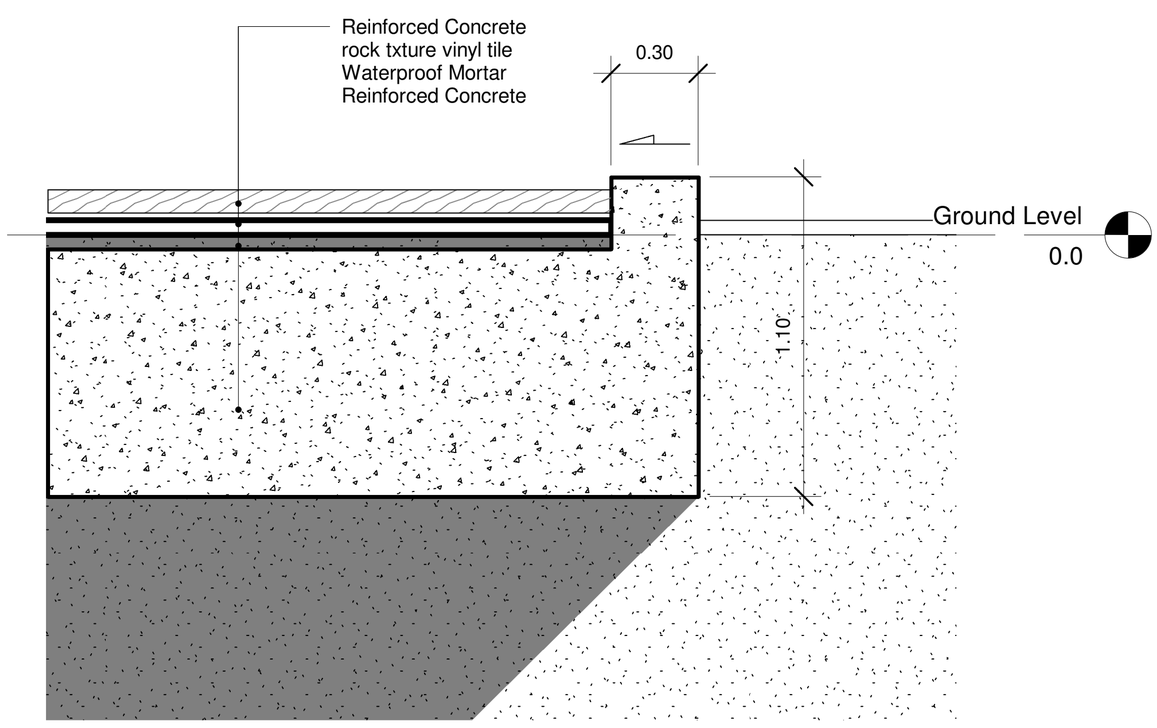
JOB / DRAWING No. OMM-A119

REVISION



1 Section C-C' - Callout 2

1 : 20



2 Section D-D' - Callout 1

1 : 20

CLIENT: NONE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A3 SHEET

SANYUNG LEE

Rev.	AMENDMENT	DATE

OMM - Onkalo Monumental Museum
Finland
Section Detail 2

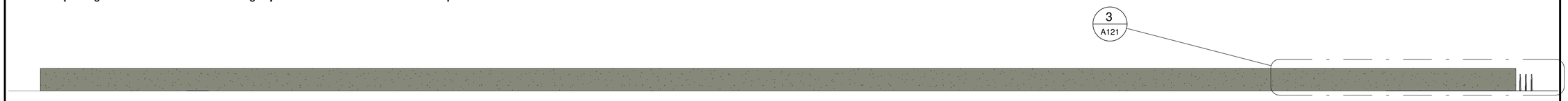
SCALE: 1 : 20

DRAWN: Author

JOB / DRAWING No. OMM-A120

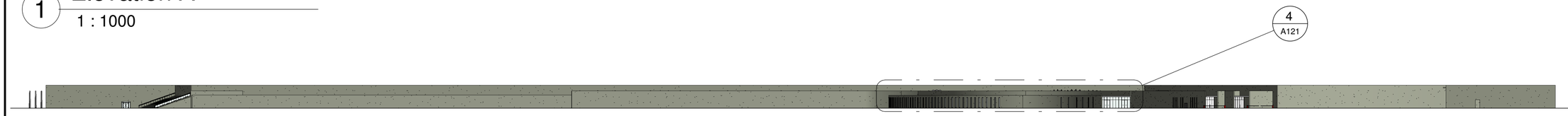
REVISION

***For maintain the minium quality of elevation, I use A2 size sheet that not like plans and sections. like section, I put large scale elevation and then enlarged partial elevation which considered important.**



1 Elevation A

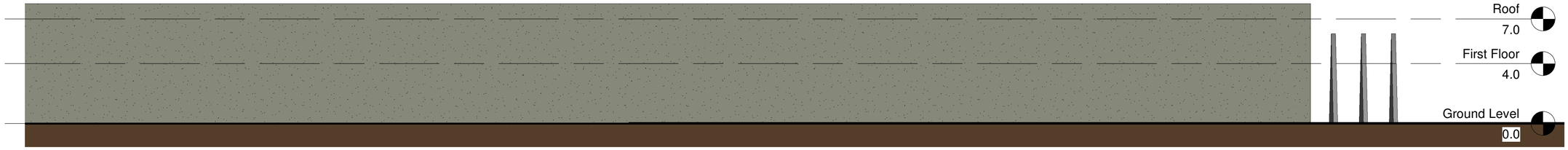
1 : 1000



2 Elevation B

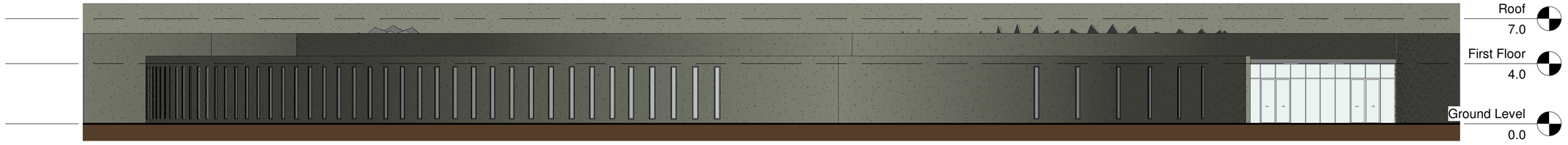
1 : 1000

0 5 10 20 50 Metres
GRAPHIC SCALE 1:1000



3 Elevation A - Callout 1

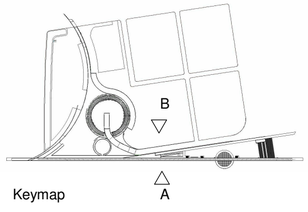
1 : 200



4 Elevation B - Callout 1

1 : 200

0 4 8 12 16 20
GRAPHIC SCALE: 1:200



Keymap

CLIENT:

NONE

SANYUNG LEE

0 10 20 30 40 50mm
PRINT REDUCTION BAR | A2 SHEET

AMENDMENT

No.	DESCRIPTION	DATE

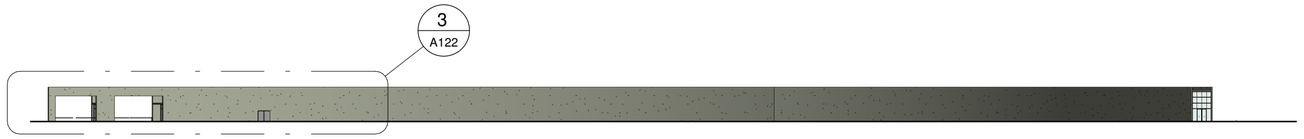
OMM - Onkalo Monumental Museum
Finland
Elevation A2 1

SCALE	As indicated
DRAWN	Author
APPROVED	

DRAWING No. OMM-A121

REVISION

***For maintain the minium quality of elevation, I use A2 size sheet that not like plans and sections. like section, I put large scale elevation and then enlarged partial elevation which considered important.**

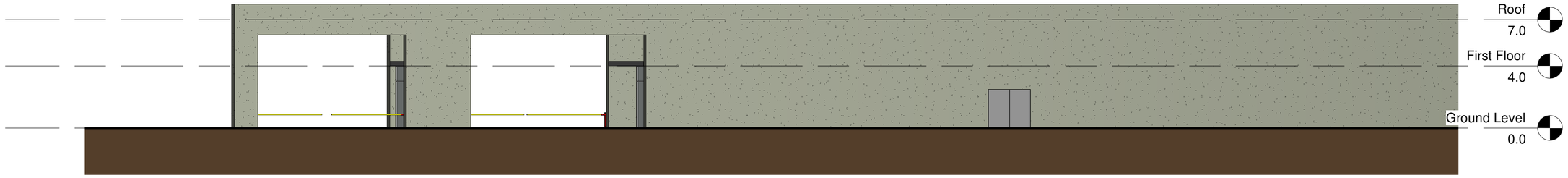


1 Elevation C

1 : 1000

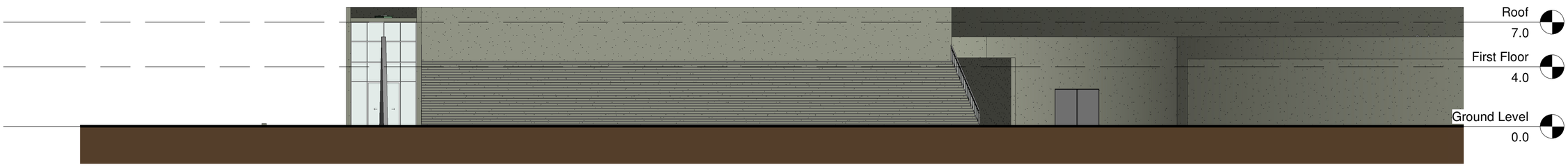
2 Elevation D

1 : 1000



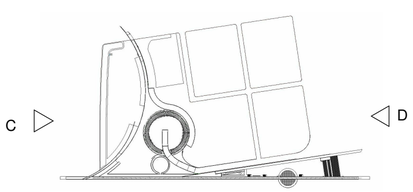
3 Elevation C - Callout 1

1 : 200



4 Elevation D - Callout 1

1 : 200



Keymap

CLIENT:

NONE

SANYUNG LEE

0 10 20 30 40 50mm

PRINT REDUCTION BAR | A2 SHEET

AMENDMENT

No.	DESCRIPTION	DATE

OMM - Onkalo Monumental Museum
Finland
Elevation A2 2

SCALE	As indicated
DRAWN	Author
APPROVED	

DRAWING No. OMM-A122

REVISION